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BERDAN'S RANGE FINDER.

THE accompanying illustrations show the latest developments of the range finder invented by General Hiram Berdan, of this city. The engravings have been furnished to us by the General, and have also been published in London in the *Engineer*, from which paper we take the following description: It may not be out of place to explain to our non-military readers that a range finder is an instrument by the aid of which the distance of any object can be determined almost at a glance. It consists essentially of two telescopes, placed some feet apart, and when both these telescopes are directed to the same object at a distance, it is evident that the axes of the telescopes are no longer parallel. Lines drawn through the object and the axis of each telescope will form the sides of a triangle, while a line connecting the two telescopes will form a base, as in the following diagram, where A A are the telescopes and B the object whose distance is to be ascertained. If the object were at C the angle of the telescopes with each other would be different Once the length of the base D and the angles A A are known, it is easy to determine the distance of the object B from the observer by a simple trigonometrical formula. Fig. 1 represents a side view of instrument No. 6, with the instrument partly turned —doors opened—to show that the instrument can face in any direction, without reference to the position of the wagon, or the base of the turret. This instrument has a fixed base, two telescopes, and a recorder that indicates the distance direct. The base is 4 meters long; the telescopes 1⅕ meter long, with object glasses 90 mm. in diameter; and the recorder is graduated to 10,000 meters. The average time required for taking the distance is thirty seconds, and the errors, whether to stationary objects, or to ships, or troops in motion, are within the mean of full and fine sights when the distance is known. This instrument is especially recommended for sea-coast and fortification batteries. Fig. 2 represents instrument No. 7 packed on a horse, the case with instrument on one side and the frame folded on the other side. Fig. 3 represents instrument No. 7 in position, ready to be operated. This instrument has a base of 1⅘ meter, telescopes 1⅕ meter—packed lengthways of the instrument during transportation—and the recorder is graduated to 6,000 meters. The capacity of No. 7 is just half that of No. 6. The base is less than one-half the size, but the telescopes are more than one-half the power, so the results are the same as with No. 6 at one-half the distance. The time required to operate the No. 7 is about the same as the No. 6. No. 7, with frame, weighs only 70 kilos, while No. 6 weighs about 1,000. The telescopes as well as the base must increase with the distance, consequently the weight and cost increase in a still greater proportion. The No. 7 could be used to very great advantage for sea-coast batteries, but in General Berdan's judgment there is no instrument that can take the place of the No. 6 for these large stationary guns on account of its great accuracy, even to objects in motion at long range. The cost of ammunition saved and the increased number of hits would soon pay for the extra cost of the instrument. The No. 7 was made for field and mountain artillery and for ship-board. When either of the ships is approaching the other, or the ships being attacked by torpedo boats, the instrument should be set to a distance short of the enemy, the sights on the guns set to correspond, and the guns kept trained on the enemy so as to be ready to fire all the guns when the vertical hairs in the telescopes cover the same point. The instrument should then be set to a shorter distance and the firing repeated if necessary. General Berdan is making an instrument, No. 8, for infantry, on the same system as No. 7, but smaller and lighter. It is to be transported on the march on a horse like the No. 7, but to be carried by pioneers on the battlefield like a stretcher and operated by them. The horse with the pioneers' tools—except their spades, which they may need to throw up a breastwork to cover themselves and the instrument—is to be left in the rear of the regiment. The instrument, of course, will be kept on the flanks of the regiments out of the line of fire, and under cover as much as possible during an engagement. The same with the artillery instrument.

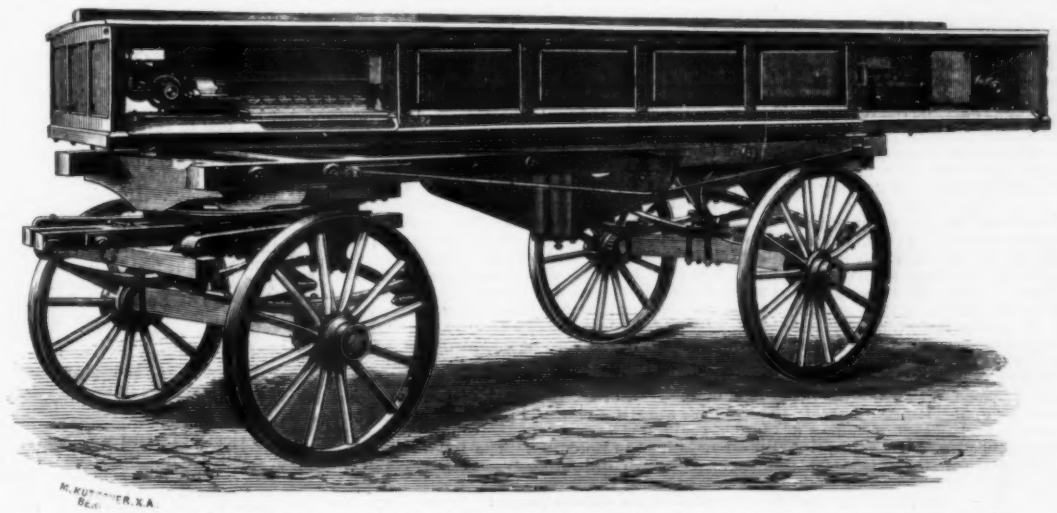


FIG. 1.—THE BERDAN RANGE FINDER, FOR FINDING DISTANCES BY TELESCOPES.

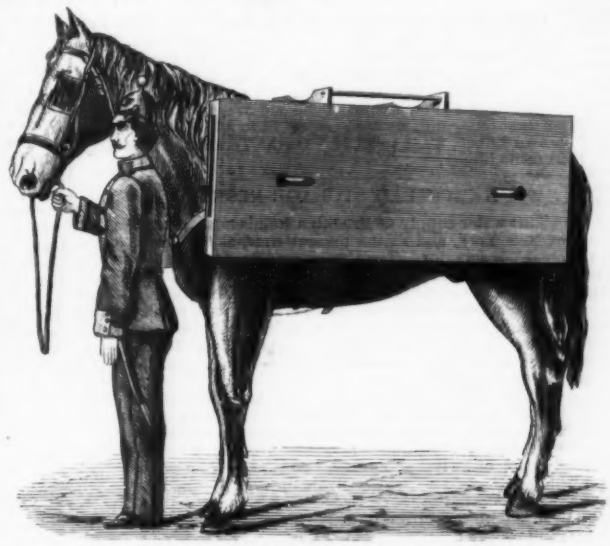


FIG. 2.—THE BERDAN RANGE FINDER.

General Berdan justifies the weight and cost of his instruments very satisfactorily. He experimented for eleven years with a great variety of small cheap instruments; first with a single glass and double refracting quartz, at West Point, in 1861. The image was too indistinct, and base too small; then followed a great variety of instruments with measured base, instruments on tripods, with different systems for obviating the necessity of placing the second instrument exactly at a right angle to the side of the triangle, with a recorder to indicate the distance without the use of tables, but he found them of no value whatever in action, for even picked riflemen, as brave as men could be, were too nervous to adjust one telescope to its proper relative angle to the other, and the instrument vibrated too easily by the wind, as well as by the nervous touch of the men's hands; also too much time, too large an open space, and too much ground for the base, was required; so he then tried an instrument with a fixed base, first with two prisms, and one ocular in the center of the base, with recorder; then mirrors; then one telescope, one prism, and one mirror, all to be operated from one station and one ocular; but the object could not be seen with sufficient distinctness. So his experience and experiments in active service, not only proved that a range finder was a necessity, but that it must be very solid, have a fixed base with two powerful telescopes, to take the angle direct with cross hairs, in place of by reflection, and a recorder to indicate the distance. He has made seven instruments within the last six years on this system of different sizes and different proportions.

With these instruments the only thing remaining necessary, in his opinion, to make artillery as destructive as possible against troops in line, behind uncovered breast works, in ships, or torpedo boats, is a shrapnel with a fuse that will explode under all circumstances with perfect accuracy. It may be interesting to add that General Berdan claims to have made such a projectile, the details of which are now being perfected; also that these projectiles will be introduced by Herr Krupp, of Essen, Prussia, who has the right to manufacture the same.

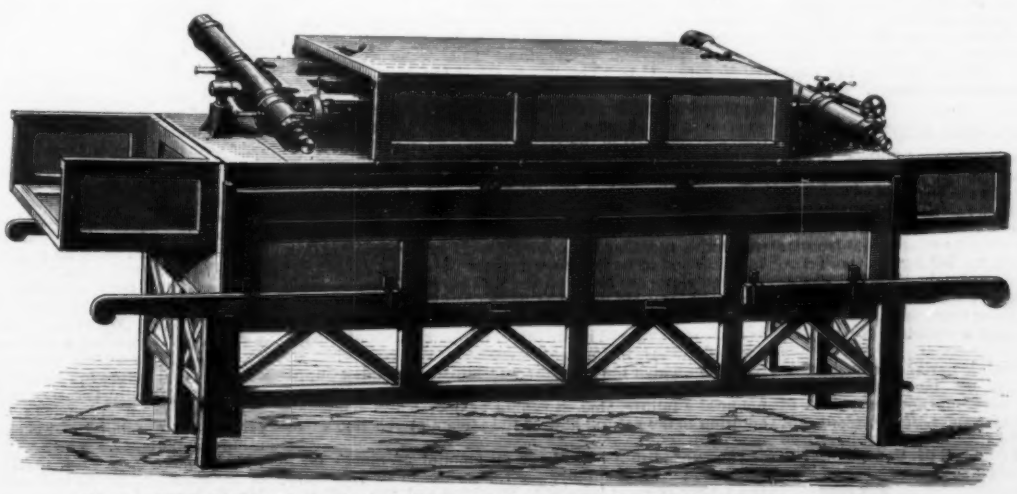


FIG. 3.—THE BERDAN RANGE FINDER, FOR FINDING DISTANCES BY TELESCOPES.

KRUPP'S LATEST PATENT.

THE patent for dephosphorating pig iron lately granted to Krupp is based upon the following: When molten pig iron comes in contact with basic oxides of iron or manganese a reaction takes place, in course of which all impurities contained in the iron, as silicium, sulphur, manganese, and especially phosphorus, are separated and converted into slag, the oxygen of the oxides being taken up by the impurities and their iron being united with the portion treated. By using a mixture of iron and manganese oxides the attack of the oxygen upon the carbon of the iron is to some extent prevented and more time afforded for the complete elimination of the impurities mentioned.

The patented invention consists of the use of the reaction described

for the purification of pig iron. The latter is, directly from the smelting furnace, conducted into a rotary furnace lined with a mixture of the oxides of iron and manganese. In case of necessity an additional quantity of these oxides may be added to the metal. The latter is now for a certain length of time exposed to the action of the oxides. As soon as signs are emitted that the carbon is being attacked, the metal is drawn off from the slag formed and may now at once be worked up into steel or iron, as desired, or cast in ingots for future use. The fact that a readily flowing iron free from phosphorus may be obtained in this manner is of great importance, as quantities as large as 5 tons may, in this case, be operated upon at once. Rotary furnaces of various construction may be used. The specification of the patent mentions those of Pernol, Danks, and Godfrey & Howson.

The crude metal is admitted into the rotary furnace, after the temperature of the latter has been brought to the melting point of the oxides with which it is lined, and the duration of the operation is from 5 to 15 minutes only The moment at which the oxides commence to act upon the carbon may be easily determined by the formation of froth on the surface. The percentage of carbon in the iron is hardly reduced, while in all respects the quality of the iron is greatly improved.—*Deutsche Gewerbe Zeitung.*

LIFE SAVING EXPERIMENTS.

THE Massachusetts Humane Society has lately adopted and presented to the Royal National Lifeboat Institution a new projectile to be fired from a light gun for saving life at wrecks. Under the auspices of the Board of Trade a series of experiments were made at Shoeburyness by the War Office authorities to prove the value of the invention. Two brass guns, perfect toys to look at, weighing fifty-six pounds and sixty-nine pounds respectively, each two feet in length, were used to fire the projectile, the charge of powder varying from 3½ to 4½ ounces.

The projectile, the novel features of the invention, weighed when filled ready for firing 12½ pounds. It is an elongated shell carrying a line tightly coiled within, which it pays out without the smallest risk of breaking as it travels through the air. It is put into the gun, as it were, the wrong or conical shot end first, and leaving the muzzle, at once reverses, the front end becoming the rear end, and maintaining, due to four wings, on the principle of the arrow, an accurate and distant range, with none of the wabbling and singing and consequent loss of power so common to the shot fired from existing rifled ordnance. In make up the projectile is a tin tube 20 inches long, 3½ inches diameter, having wings at one end and a leaden shot weighing 6 pounds at the other. Within the tube is a compact coil of line 17½ inches long and the diameter of the tube. This line is from 200 yards to 400 in length, with a breaking strain of from 250 to 400 pounds. The shot is attached to a second or short coil lying alongside the gun, so arranged that on the shock of the discharge the line runs directly from both coils.

The experiments were conducted by Captain White, R. A., assisted by the Inventor, Mr. E. S. Hunt, of Boston (Weymouth). At Mr. Hunt's range, 22½ degrees, an elevation which he found by continued practice best suited to surely throw the line over any wreck with the smallest strain to it and the projectile, the distances obtained and measured on the official range course were 389, 448, and 507 yards; the deviation of the shot and line from the target being 4 2-5ths, 9 and 8 yards respectively. Three shots fired at 30 degrees and 35 degrees elevation, traversing a line of flight some 400 feet in the air, ranged 478, 489, and 386 yards, with deviations of the shot and line from target of 2, 6, and 6 yards respectively. The force of the wind was light, blowing directly toward the line of fire, but the inventor stated that much practice in America had proved that the range and flight of the shot and line are, if anything, more accurate when firing into the eye of a gale of wind, such as generally exists when succoring a vessel on a lee shore, than in still air; while a strong wind blowing across the range interfered but slightly with the desired direction of the line, owing to the fact that the line was carried and paid out by the shot and not dragged from the shore, as is now the case with the Boxer rocket and all inventions hitherto adopted.

The principle of the projectile, and the high velocity and regular line of flight that it attained, astonished the many artillery and naval officers who witnessed the experiments. The idea of the shot turning over immediately it left the gun without loss of initial velocity or line of direction, and of arranging the shot end to take the force of the explosion, without damage to the contents carried behind the shot end, presented quite a novel feature in gun warfare. It seems probable that the gift of the Massachusetts Humane Society, presented to this country from kindly and philanthropic motives, for the purposes of saving life, will shortly be tried with very different objects in view, as it is in contemplation to replace the line by some five pounds of rocket composition, so that the shot, when it has nearly reached its greatest range of, say 2,000 yards, may have a fresh energy imparted to it, which combination of gun and rocket power will not unlikely give an effective and accurate range of about two miles. Another idea is to fill the case with inflammable material and compressed gun-cotton powder, for setting fire to and destroying villages and for general savage warfare; while a third idea, without enumerating others which readily suggest themselves to the inventive minds of diabolical gunners, is to fill the large space now occupied by line with material somewhat after the nature of the Shrapnel shell, thus producing the most murderous missile ever fired from light ordnance.

THE BILBAO IRON ORE BEDS.

IN an account of the famous ore mines of Bilbao, Spain, Prof. Nordenstrom, of the Swedish School of Mines, says that little is known about the mode of occurrence of the ore, as no works of exploration have been carried out, only the ore coming to the surface having been followed. There is even some uncertainty as to the formation to which the deposits belong. In general it is supposed to belong to the Trias. The nearest rocks occur mostly in strongly-disturbed strata, and consist, both in the hanging and footwall, of sandstone and argillaceous slate. Above these there is a bed of blue sandstone, which is looked upon as a member of the Lias formation.

The ore itself, the color of which is partly of a yellowish-brown, partly red, is spathose iron ore, more or less completely changed into hydrated peroxide and protoxide of iron, and on the spot has various names, *Rubio, Campanil,* and *Vena dulce,* according to the quantity of spathose iron which it contains. Its average contents of iron amount to 52 and 58 per cent., and it contains:

	Per cent.
Manganese	0·5 to 1·0
Lime, from traces to	— to 4·0
Magnesia	— to 0·5
Alumina, only a trace	— to —
Phosphorus, from traces to	— to 0·02
Sulphur, from	0·01 to 0·165

According to a recent map of all the mining claims, they are nearly continuous for a length of 11 miles and a breadth of 2½ miles, but it is not yet quite certain if ore is found in paying quantities in all these claims. By work which has been carried out within those that belong to the Trias group, it has been ascertained that the ore here comes to the surface over an extent of 1,000 acres, and it has been calculated that there still remain in sight, to be extracted by open workings alone, 100,000,000 tons.

The certainty that the deposits of ore are so large has rendered deep explorations unimportant, although the position of the ore at several places is such that prospecting can be carried out with comparative ease by means of adit levels. The greatest depth to which the ore has been followed, by sinking from the surface, is 200 feet.

The ore, for the most part, is extracted in a rather irregular way. In consequence of the favorable circumstances under which the raising has been carried on, a large quantity of ore could be obtained yearly, and at a low figure. It is stated that the cost of raising in general varies between 10 and 20 cents per ton. The miner's daily pay is 30 cents.

From the mines situated far up the mountains—1,000 to 1,300 feet above the sea—the ore is commonly carried in small carts to the railways in the slopes below, on which it is afterward transported to the harbors at Portugalete and Bilbao. Wire tramways are also used for bringing down the ore from the mines.

Of the seven different companies which carry on mining here, six are English and one Franco-Belgian. All the ore raised by them is exported, partly to England, partly to Channel and North Sea ports. There are no statistics showing how much is mined by these companies; but it is stated that the annual export of ore amounts to 1,000,000 tons. The ports to which all this ore is commonly sent are Cardiff, Calais, Boulogne, and Antwerp. In rare cases it has been loaded for Rotterdam and other North Sea ports, because the freights are always much higher than to the above-mentioned places. The ore is partly carried by steamers which can load 800 to 900 tons, partly by sailing vessels, the latter being employed, however, only during the finer season of the year, or between 1st May and 1st November. The freights are always lowest to Cardiff, because a return cargo of coal can always be counted on from that port to Bilbao or at least to Bordeaux. The following table shows the price at which Bilbao ore was delivered both in this English port and at Boulogne and Antwerp last year, also the freights to each of these places:

		Per ton.
Price at Cardiff		$3.89 to $4.13
"	Boulogne	4.45 to 4.83
"	Antwerp	5.23 to 5.62
Freight from Bilbao to	Cardiff	2.19 to 2.43
" "	Boulogne	2.90 to 3.30
" "	Antwerp	3.10 to 4.07

Carried further by rail, it cost last year at the blast furnaces in Westphalia and Belgium in general about $6.56 per ton, or more, according to the distance. At the Longwy blast furnaces, in the northeast of France, it is said last autumn to have cost $7.53 per ton. The current quotations for delivery ex ship are, at Tyne and Wear ports, England, for Red Campanil, Somorostro, $3.54 to $3.66, and for best brown Bilbao, $3.42 to $3.54. On the Tees the figures range 24 cents higher.

HEMPSTEAD STORAGE RESERVOIR.

THE water supply of Brooklyn stands next in rank to that of New York, and at the present time, as to facility of increase, is superior. The Croton aqueduct is 7 ft. 5 in. wide, that of Brooklyn being 10 ft. The supply now controlled and used is about one-third that of New York, with one-half the population, but as the waste is much less, Brooklyn has suffered no inconvenience, while the enlargement of the Croton aqueduct and supply is a formidable item of cost. Using water filtered through extensive sand plains, its purity is a great advantage.

In 1871 Brooklyn was induced to authorize an expenditure of $1,400,000, for a storage reservoir in Hempstead valley, at the easterly end of the aqueduct, intended to store 1,000 millions of gallons, in a structure two miles long, with a depth of 19 feet at its dam. According to the theory of the engineers who advised it, this was to be filled from the surplus storm flow of the basin of that creek, without interfering with the ordinary daily run of the stream of eight millions per day.

The plan, the excessive expenditure, and the manner of letting the contract made a great deal of discussion at the time, but the contract was let in January, 1872. In 1875, the work, still being incomplete, was stopped on account of the exhaustion of the appropriation, and left by the contractors in an unfinished state. Subsequently, by direction of the Common Council, the dam was completed, and the reservoir brought into partial use.

The house of D. Van Nostrand have just issued an engineering review of this construction by the engineer who made the plans and specifications of the water works, Samuel McElroy, C.E. The author takes the ground that the place was injudicious as the source of an additional summer supply of ten millions per day, for the reason that there was an error in the statements of defective supply made at the time and repeated in the series of annual reports; that the available drainage of surface storm supply was limited, being about one-fifth the area estimated by the engineers; that the location is in a natural filter bed, which will not successfully impound water above the level of an extensive saturated bed, which slopes up from tide level to the central hills; and that the contract itself was unreasonable in its prices and in its improper manner of letting.

These views are based on the laws of supply and demand presented, and are sustained by the detailed results of tests made in 1876 and 1878, which show that a rainfall of 10·22 in. in one case, and 9·92 in the other, impounded about 331 millions of gallons, including the entire stream run, when the theory on which the reservoir was built promised a supply of about 1,600 millions. The entire result is, therefore, pronounced a failure, since it cannot be operated as a practical addition to the natural flow of the stream at the line of the new dam.

The expenditure of so large an amount of money on so prominent a water supply, and this criticism of its results, is a matter of great interest to Brooklyn and the civil engineer profession.

[Continued from SUPPLEMENT No. 174, page 2763.]

THE TREATMENT OF IRON TO PREVENT CORROSION.

DISCUSSION.

SIR ANTONIO BRADY said he had one of the specimens shown by Prof. Barff on the first occasion exposed ever since, and it was as perfect as any now produced. It occurred to him that if the iron plates of our ironclad ships could be protected, it would confer a blessing on the nation.

Dr. Russell said he looked at this process rather as a chemist than as a practical man, and, from a scientific point of view, it was no doubt one of great importance. Last July twelvemonths, Prof. Barff gave him a specimen of cast-iron which had been coated by the first process, and he took particular interest in it, because he pointed out that it was imperfect, and evidently it was, because there were two or three little specks of rust upon it. He had kept it exposed ever since in a conservatory, where it had been every day alternately wet and dry, and had been kept at a tolerably high temperature, and on that day examining the specimen, it was evident that that part which had been protected had remained perfectly intact. Moreover, the oxidation had gone on very little indeed on those parts which were exposed, so that practically this piece of cast-iron was really in very much the same condition as it was last July twelvemonths.

Prof. Graham said that one or two years ago Prof. Barff gave him one or two small articles, and since then had supplied him with several others for the purpose of exhibiting at one of his lectures. Having heard in the north of England one or two unfavorable remarks with reference to the success of the process, he had tested these articles in a way similar to that just described—not in a greenhouse, but in a laboratory, where he had hydrochloric acid and other oxidizing vapors. He found that some stood remarkably well, though one or two showed the usual sign of rust. Of this Prof. Barff had given the explanation. The fact was that these particular articles supplied to him were prepared at a time when he had hardly discovered the right way to do it. This was really the cause of one or two of the failures in the north of England. They have not had the steam at a higher temperature than the article. The temperature of the steam must be at least 400° or 500° higher than the article submitted to it, and that would make the process a perfect success. He considered it a most successful one, and a great boon to this country. A question had been put with reference to large plates, and to it, he believed, at the present moment a definite answer could not be given, because the element of cost was one he was not able to speak confidently about. Prof. Barff had not told him how he proposed to produce superheated steam at 800° or 1,000° in large quantities, so that very large chambers could be heated up by it, and large articles might be coated. He should very much like to hear this.

Dr. Poor said Prof. Barff, some months ago, gave him a door-handle, which he had had lying about in the house. While everything else made of iron or steel was rusting, or rapidly decaying, this remained perfectly sound. No householder in London would, if he could help it, have any of the fittings in a room made of iron, for it was well known that iron rotted quicker than almost anything else. Curtain hooks, locks, and things of that kind, if not constantly attended to, very soon became useless, but this method offered a solution of all these difficulties. He was one of those who believed that the great feature of gas was for heating rather than for lighting purposes, and he has gas stoves put in his own house, but he found that one of the difficulties of ordinary gas fires, as made with asbestos, was that the iron burner very quickly got coated with oxide, and the gas burnt as in an ordinary burner, smoking instead of burning properly. Prof. Barff had treated one of the burners for him, but with only partial success. The corrosion had not been so extensive as before, but there was a good deal of it, and also of rusting; but he should state that it was done under very disadvantageous circumstances, the burner being already made up, and Prof. Barff explained to him that the steam could not properly act on all the surface of the iron, and he was going to try another, from the manufactory, which no doubt would be successful

Admiral Selwyn had great pleasure in pointing out the importance of the whole subject, and also referred to the unreasonableness of those who, when an inventor put before them something new, expected it to be as perfect in every respect as if it sprang, like Minerva, fully armed from the brain of Jove. They could not expect perfection at first; but, even if they could attain to a very small degree of perfection in this matter, the result would be of great importance, particularly in those iron structures which were rapidly replacing every other form of construction, giving an enormous degree of stability, such as could not be looked for at present. For instance, when the Britannia bridge was erected, it was perfectly well known that its life was limited, and that those parts into which you could not get to paint after construction must necessarily wear out sooner or later. This was a most important matter, because, not being able to enter the bridge, we could not see exactly what was going on, so that an accident might happen at any moment, and after a certain number of years a large expense would have to be incurred, which might have been avoided had a small portion of these results been obtainable by the peroxidation of the plates before being put together. It was possible that the treatment of rivets and rivet-holes might not be quite so satisfactory; but that was a detail for the manufacturer rather than the inventor. With reference, again, to the girders, which were largely used in underground railways in London, no one could stay long at one of the stations without remarking the fearful extent to which corrosion was going on, so that sooner or later, a large portion must be taken out at one time, with a serious interruption to the railway traffic. All this might, by such an invention as this, have been avoided. In all inventions there were three phases: first, when the thing put forward was said to be no good; secondly, when it was said not to be new; and thirdly, when it proved to be both new and good, and then everybody tried to rob the inventor. With regard to the subject of boilers, it was of the greatest importance that boilers should not decay as rapidly as they did. A great ironclad went to sea with her boilers capable of supporting a certain pressure, but she had not been to sea two years before her boilers were obliged to be worked at a lower pressure per square inch, and their inefficiency diminished in an enormous ratio. Anything which would give greater durability and efficiency to boilers was of the utmost importance. This was being done by an engineer, who did not see, as Prof. Barff had done, the chemical part of the question, but he had succeeded without knowing it. Mr. Perkins had made boilers which were submitted to very high temperature and pressure. Inside they were entirely

made up of tubes, about 3 inches in diameter, and were called "tubulous boilers." One of these, after it had been at work 13 years, was cut open by the Boiler Committee, and the internal surface of the tubes was found to be coated with what he should call imperfect peroxide. It was not bright and uniform in its surface as these articles were, but it had had the effect of completely stopping all corrosion, and the boiler after 15 years' working was as good as when put up. There was one point in connection with boilers which, he hoped, Prof. Barff would investigate. He had tried the action of sulphates and hot sulphuric acid, but chlorine was a much more dangerous enemy of iron than even sulphuric acid. It had a peculiar action known as "pitting," and, unfortunately, they could not get rid of the chlorine in salt water, even by distilling. With regard to the artistic work, he saw a specimen on the table which would almost deceive an amateur into thinking it was a patina of that ancient workmanship so much valued. The lines of the casting seemed to be perfect, not showing the slightest filling up of the channels or anything of that kind, and this showed that the making of iron, one of the strongest metals, into the subject of the highest artistic design, was well worthy of the attention of that society and of manufacturers. There were some people who objected to everything of this kind which provided greater durability, saying it was bad for trade, but he had no sympathy with such notions. Whatever added to the durability of what we used, added to the wealth of the nation which was able to develop such an invention. There was one point to which he was really commissioned to pay attention, and which he hoped would be borne in mind by the whole of the British public. It was this—that we ought to give more protection to capitalists—he did not say to inventors—to induce them to assist in things of this kind. It was the uncertainty of the law connected with the protection of inventions which prevented capital raising up in this country trades and manufacturers which would replace the stable articles of which we had lost the monopoly, and would enable us to pay for our food, as we had very little prospect of doing at the present moment. If the desire was to see the industry of this country raised to its old level, it would not be accomplished by any repressive means, still less by insisting on human nature changing, by recognizing the necessity of protecting all that kind of development which increased the wealth of the nation. As soon as this efficient protection for the labor of the inventor was obtained, he had no doubt that Prof. Barff would get rid of all difficulties in having his invention taken up. Manufacturers saw that there necessarily must be some tentative work, and they did not desire to engage in it, to see the whole profits of their labor taken away fro 1 them because everybody could do the same. Whether they regarded this process as a question of protecting water-pipes underground or pipes in mines, or as a question of art or of utility, it was equally important that such an invention should be thoroughly understood and carefully investigated.

Mr. Liggins said he came specially to hear if this invention was likely to be applicable to shipping, a subject in which he had been interested all his life. As iron and steel ships were superseding wooden ones, he felt anxious to know if this process would prevent the corrosion of ships by sea water. Up to the present time this had not been accomplished. Paints wore off, rubbed off, and rotted off in a way that was anything but satisfactory to shipowners; and if this process were applicable, it would no doubt be a great success. The specimens presented seemed to indicate that the process must be applied to large surfaces; but even apart from that, it was well known that in the minor parts of ships iron was largely protected by the galvanic process. But there were objections to it, because it was alleged to diminish the strength of the iron, and in many parts great strength was required. He alluded especially to some of the bolts, which were so essential to the safety of the rigging, and to cables and anchors, upon which the safety of the whole ship depended. He remembered when the galvanizing process first came up. An anchor so treated was supplied to the royal yacht Victoria and Albert, and some doubts were expressed as to whether it would be safe, owing to the heat of the process it was subjected; but it has since become universal on board yachts, and he had ridden out some very heavy storms in large yachts where the anchors and cables were both galvanized. The comfort of a galvanized cable on the deck of a beautifully-kept yacht was very great, for nothing made a greater mess of a clean deck than a rusty cable. There were many bolts in wooden ships which were generally made of iron, rather than copper, on account of the extra strength, such as the chain plate bolt, but these were a constant source of expense, because they corroded very rapidly, so that every two years or so the ship had to be docked and the bolts replaced. He had sometimes seen them taken out in such a state that he could break them off with his fingers. He should like to know if this process would be applicable to cables, or whether the coating would be liable to be removed with the violent concussion with the iron hawse pipes when the cable was rapidly run out. He thought this one of the most valuable inventions ever brought before the Society.

Colonel Prendergast hoped the profession to which he belonged would be allowed to take its share in what he considered one of the greatest inventions of the time. It appeared that up to the present very large articles had not been put to the test which smaller ones had, but the army dealt in small articles as well as large ones, and it would be a great thing if this process could be applied to the thousand and one small details, the care of which were of immense trouble to the service. There was one unfortunate matter connected with the profession, that when peace came they were all for burnishing and varnish, and making things look pretty. At this moment, however, we were engaged in more than one war, and if they could enlist the aid of the chairman, possibly an attempt might be made to introduce this process for some of the articles now being sent out to the seat of war. Nothing but a practical test was of much use in such matters, but a few months' wear in Zululand would give every test necessary for the purpose. At the close of the Crimean war a quantity of galvanized bits were tried, but they were a complete failure. They would not stand the test of strength, and, above all, they were ugly. As far as he could see, from some of the articles exhibited, a considerable amount of beauty might be attained if the metal were properly prepared. It would be an immense boon to the soldier if he had a scabbard which would not rust, for half his day was taken up in cleaning his accouterments. He would also ask, in reference to artistic purposes, whether it would be possible to prevent any particular portion of the metal receiving the oxide if so desired?

Mr. Bromhead asked if the process were applicable to steel articles, such as axes, hatchets, and things of that kind.

The Chairman said Mr. Barff had stated that he objected to the use of air, but he was no doubt aware that there was, at any rate, one gentleman, Mr. Bower, of St. Neot's, who was carrying out a process of treatment with air—he could not say whether dry or moist air—and he claimed a certain measure of success. He exposed the articles, both of wrought and cast iron, in a current of heated air, 1,500° or 1,600° Fahr., for a period of six or seven hours. It had also come to his notice recently, that, in France, a Captain Bourdon had tried the action of hot air, and it was stated in the *Revue d'Artillerie* that he had successfully applied the process to coat gun barrels with magnetic oxide. As he described the process he had a large chamber, in which he put 400 or 500 barrels, and raised the temperature to 550° or 570° Fahr., exposing the barrels to a moderate current of air for about five hours. He said they came out coated with a loose film of red oxide, which was removed with a greasy rag, and then he found a coating of black oxide beneath, which he believed would form a considerable protective; and he had been commissioned by the Government to treat a larger number of barrels in this way. He should like to know whether, in Mr. Barff's opinion, the results thus obtained were likely to at all compare in durability with those which he had described and shown. He had inspected a large number of Mr. Barff's specimens, which had been submitted to all kinds of severe usage, and could testify to the remarkable durability of the coating he produced by means of superheated steam.

Prof. Barff, in reply, said there were on the table several specimens of riveted plates, and both the rivets and the calking were improved by the operation. It was feared at first that in fitted boilers the rivets would be started and the calking interfered with, but this proved not to be the case. Girders and riveted structures could be treated, provided the chamber was large enough, but there seemed to be some doubt about the size of the chamber. All he could say was, that Dr. Siemens had told him that a chamber of any size that could be heated could be supplied with superheated steam to properly oxidize articles of any size. The late Secretary, Mr. Foster, only a few nights before his death, was present at a conversation between Dr. Siemens and Mr. Nasmyth, when the former expressed his opinion, unhesitatingly, that the process could be applied to chambers of any ordinary size as perfectly and easily as to the small chamber in which his experiments had been carried on. Who would have imagined a few years ago that steam hammers would be employed, and that the enormous guns we now saw would be made? All these things grew as the necessity for them arose, and there was no *prima facie* difficulty in the way of articles of any size being treated. He could not say much about armor-plates at present; he was working at it, but as he had spent some thousands of pounds on this invention, with the help of a friend, he thought it was now time for the manufacturers to come forward and do something. Over £6,000 had been spent on these experiments already, and he could hardly be expected to spend another £6,000 in building a series of large chambers for armor-plates. How were these plates rolled now? Simply by enterprise. No one dreamed twenty or thirty years ago that such plates could be made; but the necessity arose and they were produced. Here was the necessity, and the thing could be done. He had some plates which had been riveted after being coated; the plates being first drilled, and the rivets and plates being coated. They had been exposed for some time, and were perfectly intact, except that the rivets had rusted where the coating had been removed by the riveting. But how long would it take for a rivet to rust entirely through its length? So that even if nothing more than that could be done, it would be a great protection, and there would be very little difficulty in a man going round, if necessary, with a pot of black paint, and touching up the heads of rivets. The smooth surface produced, which nothing stuck to, argued very much in favor of its resisting the attachment of those nasty things which cling to a ship and so much impeded its progress. He did not like to speak of what he was trying, nor would he do more now than say that his attention was being turned to this matter, and that before long he hoped to be able to coat the heads of rivets *in situ*, the plates being done first. He could not answer Dr. Graham's question about the way in which the superheated steam would be supplied to the chamber, because, though he had ideas on the subject, he had not formed a definite plan, and it was more an engineering than a chemical question; he was now being advised by skillful engineers, and he hoped that this desideratum would be attained. The main point in Admiral Selwyn's remarks was as to the action of chlorine. This could only be answered by experiment; you could not theorize about it. When he read his first papers, he spoke of certain experiments he had performed with acids, and said that the iron resisted their action, and, on repeating the experiments, he found his statements were not absolutely correct; so with regard to chlorine, if he made an assertion now, he might say something which he might afterwards have to modify. It was down on his notes that this experiment, amongst others, should have an early trial, for he knew the difficulties occasioned by chlorine, and he felt as anxious as anybody to remove them if possible. With regard to cables, as he had said, wire would not rust, but if bent beyond a certain angle the coating scaled off, so that the cable would have to be coated entire. Whether the friction would wear it off he could not say; it must be tried. If any one tried to file off the oxide from any of these articles it would take them many hours, but a few knocks with a hammer would chip it. There were many parts of a ship which could be treated with advantage. There was a screw on the table which had been in use in a yacht for a long time, and bolts could be done perfectly. In answer to Colonel Prendergast, he might say that if you coated a portion of the metal with pieces of fire-clay mixed with borax, you would prevent the formation of the oxide. Whether you could do it in sharp lines he could not say. With regard to the gas-stove sent him by Dr. Poore, it was very rusty, and it was impossible to clean off the rust from the inside of the pipe. He was going to try a new burner, which he had no doubt would turn out better. He should add that, even where there were defects in the coating, the scale never came off by the rust burrowing beneath it, and this was a most important matter. If a large girder was being put into position, it would scarcely be possible to avoid blows here and there, which would remove portions of the scale; but as the rust would not spread, it would not affect the real strength of the structure; and, in fact, if the area exposed were not large, the red oxide which formed on the iron itself acted as a protection against further oxidation, as he had proved in several instances. This was not the case with copper rusting, which would eat right through the iron. He had no wish to speak of other processes, because it might be supposed that feelings of competition would come in, but there was really no competition between himself and Mr. Bower. That gentleman had seen his process, and then devised a scheme of his own, and wrote and suggested that they should join. He replied that he should be quite willing to do so, provided his process would do what he said, and he asked him to send him the most perfect specimen he could of his process. That was a year ago last summer. He sent him a specimen at Margate, and in about six weeks' time it was rusted nearly all over. Other specimens had been shown him, which had not been so rusted, and he believed Mr. Wood had a specimen.

Mr. H. T. Wood said he had a specimen in his garden, which had been placed under a water-tap, and it had kept very well on the whole, but it was spotted in part with red rust.

Prof. Barff said some of his early failures arose from air being in the chamber. In an article on this process, it was stated that he forced air from a gas-holder, but if that were so, and the air came from a furnace house, it would be saturated with moisture, so that there would be a considerable quantity of water held in suspension, which water would be decomposed, and the iron would be oxidized. In order that it should be done by air alone, the air must be thoroughly dried, and if this was not done, he was advised that it would be an infringement of his own patent. Whatever adhesion there was of black oxide to the surface, his experience taught him was due to moisture, and that in dry air you did not get perfect adhesion at all. With regard to French experiments, he had seen a statement that, in one case, Capt. Burdon used air, and in another steam; but there was no statement as to whether or not the air was dried, and that made all the difference. He had not seen the report to which the chairman referred, but he had seen an article in a newspaper, stating that the gun-barrels were tested by dilute hydrochloric acid, and at once put it down as humbug, because no black oxide would withstand the action of that acid. It would take the coating off any of the articles on the table, and make them quite rusty. When one read a statement of that sort one lost confidence in the whole report; but he should be glad if the chairman could procure some of the gun-barrels, and test them. Steel could be treated equally as well as iron, but it lost its temper. Whether it could be retempered he did not yet know, but one or two gentlemen had undertaken to try it. Two pieces of Whitworth steel were now undergoing the process, and any gentleman who would like to see the result could do so by attending at his laboratory in Wright's-lane, Kensington, the following morning at twelve o'clock.

The Chairman said Mr. Barff had thoroughly established the success of the process he brought forward some two years ago. Like many other inventors, he had had many difficulties to contend against, and they could not but admire the truly British pluck with which he had met all discouragement. They had before them abundant proof that the process was applicable to a great variety of purposes, and it would be very foolish not to apply it to them because it had not yet been proved to be applicable to something else. There was no doubt in his mind that if the applications of it with success were extended by practical men, the occasions in which they hoped to see it applied would increase, and that though there might be difficulties perhaps at first, success would eventually follow. Some persons had even gone so far as to intimate that because Mr. Barff applied magnetic oxide to iron surfaces he claimed the idea that this oxide was a protective of his own. He would never dream of doing anything of the sort, but great credit was due to a man who, having observed that this oxide was a perfect protective, not only conceived the idea of applying it, but brought to a practical issue a means for coating with ease and comparative simplicity small articles of iron. Their thanks were due to Mr. Barff, not only for his very interesting paper, but especially for the great perseverance with which he had combated the difficulties which he had met with in carrying out the process, and he begged therefore to propose a hearty vote of thanks to him.

The vote of thanks was carried unanimously, and the meeting adjourned.

[Continued from SUPPLEMENT No. 174, page 2776.]

THE SILKWORM.

A BRIEF MANUAL OF INSTRUCTIONS FOR THE PRODUCTION OF SILK.

Prepared by Prof. CHARLES V. RILEY.

PREPARATION FOR SPINNING.

With eight or ten days of busy feeding, after the last molt, the worms, as we have learned before, will begin to lose appetite, shrink in size, become restless, and throw out silk, and the arches for the spinning of the cocoons must now be prepared. These can be made of twigs of different trees, two or three feet long, set up upon the shelves over the worms, and made to interlock in the form of an arch above them. Interlace these twigs with broom-corn, hemlock, or other well-dried brush. The feet of each arch should be only about a foot apart. The temperature of the room should now be kept above 80°, as the silk does not flow so freely in a cool atmosphere. The worms will immediately mount into the branches and commence to spin their cocoons. They will not all, however, mount at the same time, and those which are more tardy should be fed often, but in small quantities at a time, in order to economize the leaves, as almost every moment some few will quit and mount. There will always be a few which altogether fail to mount, and prefer to spin in their trays. It is best, therefore, after the bulk have mounted, to remove the trays and lay brush carefully over them. The fact that the worms already mounted make a final discharge of soft and semifluid excrement before beginning to spin makes this separation necessary, as otherwise the cocoons of the lower ones would be badly soiled. As the worms begin to spin they should be carefully watched, to guard against two or three of them making what is called a double or treble cocoon, which would be unfit for reeling purposes. Whenever one worm is about to spin up too near another, it should be carefully removed to another part of the arch. In two or three days the spinning will have been completed, and in six or seven the chrysalis will be formed.

GATHERING THE COCOONS.

Eight days from the time the spinning commenced, it will be time to gather the cocoons. The arches should be carefully taken apart, and the spotted or stained cocoons first removed and laid aside. Care should be taken not to stain the clean ones with the black fluids of such worms as may have died and become putrid, for there are always a few of

these in every cocoonery. The outer cocoons of loose or floss silk are then torn from the inner cocoons or pods, and the latter separated according to color, weight, and firmness of texture; those which best resist pressure indicating that the worm has best accomplished its work. Too much care cannot be taken to remove the soft or imperfect cocoons, as, if mixed with the firm ones, they would be crushed and soil the others with their contents. The very best of the firm cocoons are now to be chosen as seed for the next year, unless the raiser prefers buying his eggs to the trouble of caring for the moths and keeping the eggs through the winter. Eggs bought from large establishments are, however, apt to be untrustworthy, and it is well for all silk-raisers to provide their own seed. These cocoons should be chosen for their firmness, and the fineness and color of the silk, rather than for their size. Mr. Crozier says: "If white, take them of the purest white, neither soft nor satin-like; if yellow, give the preference to the straw-colored, which are the most sought after; and, last, if they are the green of Japan, the greener they are, of a dark, sharp color, very glossy, the better is the quality of the thread. Discard the pale shades in the last breed." If there are any double or treble cocoons in the batch, of the right color, quality, and consistency, they should be used before the others, as they are just as good for breeding purposes, though unfit for reeling. In estimating the quantity that will be required, the following figures will be of use: The general estimate is always made of 40,000 eggs to the ounce, and also that each female lays from 300 to 400 eggs. Taking the higher estimate, it will require only 100 females to lay an ounce of eggs; taking the lower, it will require 133. It will, therefore, not be safe to take fewer than 200 cocoons, half males and half females, if an ounce of seed is desired, and from that to 225 would be safer. While it may not always be possible to determine the sex of the cocoons by their shape, we may approximately separate them by weighing. The whole quantity set aside for breeding purposes is first weighed in order to get the average, and then each one is weighed separately, and all above the average may be pretty accurately considered females and all below it males. These breeding cocoons should now be either pasted upon cardboard on their sides, or strung upon a string, great care being taken to run the needle through the silk only and not deep enough to injure the chrysalis, the object being in both cases to secure the cocoon so that the moth can the more readily make its escape. They can be laid aside in a rat-proof place to await the appearance of the moths, and in the meantime the other cocoons should be taken care of.

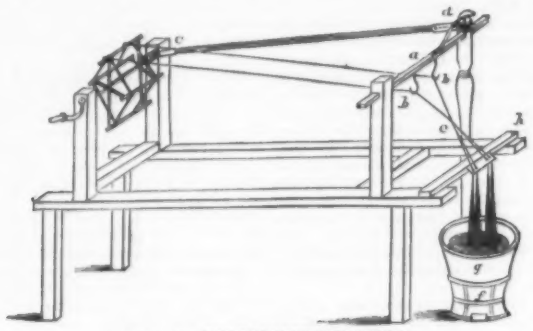


FIG. 5.—PIEDMONTESE REEL.

CHOKING THE CHRYSALIS.

In most silk-producing countries the parties who raise the cocoons sell them to the reeling establishments before suffocation is necessary, as these establishments have better facilities for this work than are to be found in private families. If, however, the reeling is done by the raiser, or some time must elapse before the cocoons can be sent to a reeling establishment, some means must be used to kill the contained chrysalis before the cocoon is injured for reeling purposes by the egress of the moth. This can be done by stifling them with steam or choking them by dry heat. Steaming is the surest, quickest, and best method, if the facilities are at hand: it can be done at any steam mill. The cocoons are laid upon shelves in a tightly-sealed box and the steam is turned in. Twenty minutes will suffice to do the required work, and the cocoons are then dried in the sun. The dry-heat method occupies a much longer time. The cocoons are placed in shallow baskets and slipped on iron drawers into an oven which is kept heated to a temperature of about 200° F. This should not be increased for fear of burning the silk. This operation lasts from two to twenty-four hours. A certain humming noise continues so long as there is any life, and its cessation is an indication that the chrysalides are all dead. Where the choking is well done there is little loss, only about one per cent. of the cocoons bursting at the ends. After choking in this manner, the cocoons should be strewn upon long wooden shelves in the shade, with plenty of air, and, for the first few days, frequently stirred. After remaining on these shelves for about two months, with occasional stirrings, the chrysalides become quite dry and the cocoons will preserve indefinitely. They are, however, still subject to the attacks of rats and mice, and the little beetles known as "museum pests," belonging to the genera *Dermestes* and *Anthrenus*, are attracted by the dead chrysalis within and will penetrate the cocoon, injuring it for reeling purposes. In the warm, Southern States the dry-heat choking can be accomplished by simple exposure to the sun. This was done by M. L. Prevost in Southern California, and is practiced habitually by Mr. Crozier in Silkville, Kansas, who says: "Here the cocoons need only to be fully exposed to the rays of the sun, from 9 o'clock in the morning till 4 o'clock in the afternoon. Two or three days of such exposure are sufficient. But, as some time strong wind can annihilate the effect of the sun's warmth, it is good to have for that purpose long boxes, 4 feet wide, sides 6 inches high, to be covered with glass frames. This will increase the heat, and, by absorbing the air of the box, stifle your chrysalis most surely." Ed. Müller, another California grower (Nevada County), always makes use of this method of stifling by the sun's rays, but says that the glass cover of the box should be left open a crack to allow the evaporation of the moisture, which otherwise would collect in large drops upon the glass, and, falling back upon the cocoons, would keep them moist for a longer time. Do not, however, allow the ants to creep in at the crack, as they too will penetrate the cocoon to feed upon the chrysalis.

In the colder climates it has been suggested that the chrysalis could be well choked, with no injury to the cocoons, by placing them in a vacuum box and exhausting the air. Chloroform has been used to a certain extent, and experiments are now being made in France with sulphydric acid gas, a vapor which is evolved from the mixture of dilute sulphuric acid and sulphide of iron; also with bisulphide of carbon.

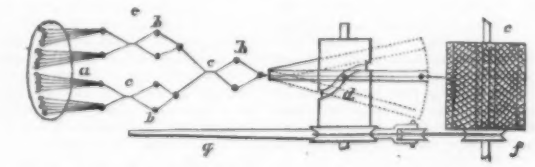


FIG. 6—PLANE VIEW OF OLD FRENCH REEL.

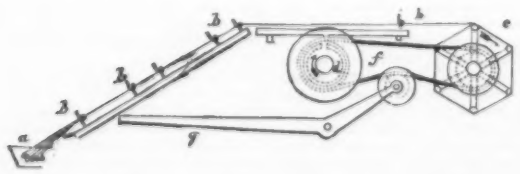


FIG. 7.—SECTION OF OLD FRENCH REEL.

EGG-LAYING—REPRODUCTION.

In from twelve to twenty days from the time when the worm commenced to spin, the moths will begin to issue from the cocoons laid aside for breeding purposes. They issue most abundantly during the early morning hours, from four to eight o'clock, and as they appear, they should be taken by the wings and the sexes kept apart for a short time. The males may be readily distinguished from the females by their broader antennæ and smaller bodies, as also by the incessant fluttering of their wings. The females remain comparatively quiet, their abdomens being heavy and distended with eggs. A few hours after issuing, the sexes, in equal numbers, may be placed together, great care having been taken to destroy any that are at all deformed, in order to keep the breed as fine as possible. They should be placed upon paper or card-board, and the room should be kept as dark as possible in order that the males shall not uncouple themselves. For the complete impregnation of the eggs, the sexes should be kept together six hours, neither more nor less; and occasionally visited in order to replace those males which may have become separated. Should there, on this day, more males than females issue, the superfluous males may be put in a closed box and kept till the next day, when the state of things may be reversed. Should there, on the other hand, be a superfluity of females, a sufficient number of the strongest and most vigorous males should be uncoupled at four hours and placed with the unpaired females for six hours more. As the pairs are uncoupled at the end of six hours, care should be taken to injure neither sex. The female should be held by the wings with one hand and the abdomen of the male gently pressed with the other. The males may then be laid aside in a box, as there may be use for them before all the moths have appeared. After all the females are impregnated, however, they may be thrown away. These last, as soon as separated, should be placed for a few minutes upon sheets of blotting-paper, where they will free themselves of a quantity of greenish-yellow fluid. From the blotting-paper they should be transferred to trays lined with cloth upon which the eggs are to be laid. This cloth should be of the smoothest sort of woolen stuff rather than of linen or paper, if it is desired to remove the eggs at a future time, as they will stick so fast to the latter that it will be difficult to remove without bruising them. Upon these trays they may be placed in rows, and will immediately commence depositing. It is advisable to tip up the trays at one end so that they incline a little, as the moths are then more apt to lay their eggs uniformly. They should also be kept in the dark, in accordance with the nocturnal habit of the moth. The temperature of the room should be kept at about 75°, and plenty of air given during oviposition. All of the thoroughly impregnated eggs will be laid in about twenty-four hours, and the moth should be removed after that length of time. She may continue depositing a short time longer, but the eggs should be kept by themselves and not mixed with the others. It will be well, also, if the best and purest breed be desired, to keep the eggs of those moths which were coupled with males that had been used before, separated from the eggs laid by those which were coupled with virgin males. "The eggs are best preserved on the cloth where originally deposited, as they are protected by a natural coating of varnish, and, being fastened, the worms, when hatching, eat their way out better. For commercial purposes, however, they are usually detached during the winter by immersing the cloth containing them in cool soft water for a few moments; the moisture being then drained off by means of blotting-paper, and the eggs gently removed with a paper-knife. They are then washed in soft water, thoroughly dried, and put away for keeping. All eggs which swim on the surface are considered bad and discarded. The Japanese producers sell their eggs on cards or cartoons made of coarse silk. The cards are placed in wooden frames, the rims of which are varnished, so that the moths —disliking the varnish—are made to confine their eggs upon the cards, which are consequently covered in a very regular and uniform manner."

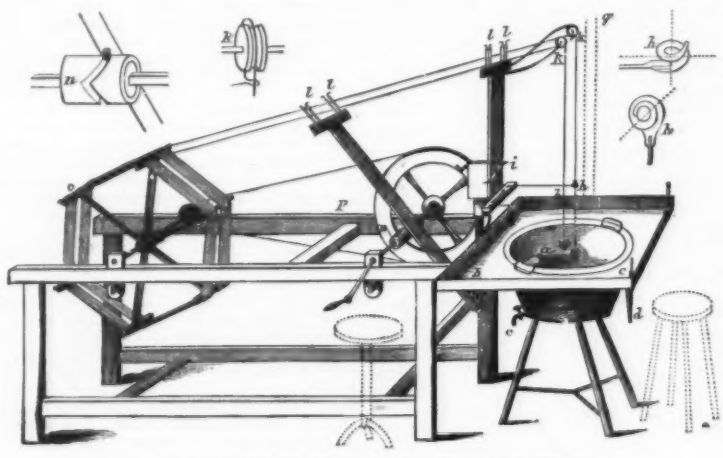


FIG. 8.—IMPROVED LOMBARDY HAND REEL.

The egg retains the characteristic color of the unimpregnated ones—light yellow—for twelve or fifteen days, when it gradually acquires the gray, lavender, or greenish tint of impregnation. The moths live but a few days after having perpetuated their kind.

REELING.

"If the mere rearing of the worm and the production of the cocoons is simple, the reeling of the silk is by no means so, as the greatest skill is required to accomplish the work properly, and the value of a hank of silk depends as much on the skill of the reeler as upon the quality of the original thread. In the best cocoons the silk will measure upwards of a thousand feet in length, and, though it appears single, it is in reality composed of two threads, which are glued together and covered as they issue from the spinneret of the moth with a glossy varnish, which enables the worm to fasten the silk where it wills, and which is soluble in warm water."

In countries where there are steam-reeling establishments, it is generally more profitable for the small raiser to sell his cocoons, and not go to the trouble and expense of reeling by hand; but, unfortunately, there is no market for choked cocoons in this country, and the raiser will be under the necessity of reeling his own silk, if he wishes to make the most of them. It will be desirable, then, in this paper, to state the facts and principles which should govern the unwinding and reeling, for the benefit of those who may wish to use single basins and reels worked by hand. In the great reeling districts of France, everything is brought to such perfection in the *filatures*, or reeling establishments, by the aid of steam, that the hand-reels have there almost gone out of use. But most of the silk is unwound by hand-power in

China, and excellent silk may be made by dexterous management with a good hand-reel.

"Raw silk is classified into organzine, tram, and floss. Organzine is considerably twisted and is the choicest. Tram is made from inferior cocoons and is but slightly twisted. Floss is made of the loose silk, carded and spun like cotton or wool.

"The thread of silk as it unwinds from the cocoon is valueless for manufacturing purposes, several of them combined going to make the staple of commerce. The persons employed in unwinding silk are mostly women, one standing or sitting before each basin, of which she has entire charge. The basin is made of copper, and, in the large establishments, the water in each basin is heated by steam, at the control of the operator. The cocoons are plunged into the water, when it is near the boiling point, and moved about so that the gum which fastens the threads becomes uniformly and thoroughly softened. They are then beaten with a small birchen broom, having the tips split, so that the loose threads readily fasten to them. After beating a short time, the operator gets all the cocoons fastened, and, taking the bundle of threads, shakes the cocoons till each hangs but by a single one. She now takes up five or more threads (*brins*), according to the quality of silk wanted, unites them, and introduces the combined staple or strand (*fil*) into a little glass eye on one side of the basin. She then forms a second similar strand and introduces it into a second eye on the other side. The strands are then brought together, twisted several times, separated above the twist, and introduced into two other glass eyes or ringlets, through which they are led, one to each end of the reel or *tambour*, which is kept revolving in a steady, rapid manner, and to which is also given a certain back-and-forth side motion. The great object in reeling is to get the threads uniform, rounded, well joined, properly freed from moisture, and so crossed on the reel that they will not stick or glaze, as it is termed. These objects are attained by the twisting and the to-and-fro lateral movement of the reel, as also by properly regulating the distance between reel and basin. The uniformity of the thread depends on the skill of the operator, who must supply a new thread as soon as one begins to give out. This is called nourishing the silk, and is done by dexterously casting, with the thumb, the new thread upon the combined strand, to which it immediately adheres. In this she must use much judgment, for the silk of a cocoon gradually gets lighter and finer as it approaches the end, and the uniformity of strand does not entirely depend on the uniformity in number of the individual threads forming it. Whenever the silk rises in locks the temperature of the water is known to be too hot, and when it unwinds with difficulty the temperature is, on the contrary, too low. The operator is supplied with a skimmer with which to remove all chrysalides and refuse silk; also, with a basin of cold water in which to cool her fingers, which are being constantly dipped in the hot basin. This constitutes the whole operation of unwinding, but before the skeins, as they come from the reel, are ready for the manufacturer they must undergo still further manipulation. The staple is first passed through a cleanser, consisting of a clasp lined with cloth, which catches any loose silk or other matter that may be adhering to it. It is then further cleansed and purged by being passed through four similar cleansers (*purgeurs*), then twisted about 500 times to the yard, then doubled and again twisted about 400 times to the yard. It is finally run on to reels about 1½ feet in diameter, and taken off and twisted in a peculiar knot or hank. Through all these operations the oscillating to-and-fro lateral motion is kept up, so as to produce the diagonal crossing of the strands, and it will be readily understood that each staple is, in the end, composed of ten or more of the simple threads first spun by the worm.

"The loose or flock silk, together with all which, from one cause or another, cannot be reeled, is soaked in water for three days, boiled for one half hour in clear lye, washed in rain-water, and when dry, carded, and spun it makes an inferior floss silk."

In order to better illustrate these principles, we have introduced figures of three reels. Fig. 5 is the old Piedmontese reel, which for many years held its supremacy, and which has been the foundation of numerous improved reels. It is formed of four bars or arms, and is usually about a yard in circumference. One of these bars is provided with hinges so that it may fold inwards towards the center when it becomes necessary to slacken the silk in order to carefully remove it from the reel. The lateral movement so necessary in order that the consecutive circles shall not stick together is gained in rather a clumsy manner by means of cogs. The strands after being twisted several times at *c*, in order to round and smooth the threads by friction, are passed over the guides, *b b*, which are inserted in the traversing bar, *a*. To this bar the lateral movement is imparted by a pin connected with the outer circumference of the cog-wheel, *d*. This is connected at *e* with the cog revolving with the shaft of the reel. *f* represents a charcoal-furnace under the copper basin, *g*. The cross-bar, *h*, to which are attached the glass eyes through which the threads from the cocoons first pass, is usually widened into a shelf, upon which to place the broom and the cold water for the reeler's fingers.

Figs. 6 and 7 represent, respectively, a plane view, seen from above, and a longitudinal vertical section of an old French reel differing somewhat from the Piedmontese, and the principles of which are employed in all the improved reeling establishments of to-day.

a. The oblong water-basin heated by a charcoal-furnace or by steam, and frequently divided by partitions.

b b. Hooked wires or eyelets to guide several threads and keep them apart.

c c. Points where the threads are twisted upon each other to clean their surfaces and compactly round them.

d. Cylinder on shaft, with a spiral groove in its surface, in which fits a pin from the traversing-bar, thus giving the lateral movement to the thread which goes through a guider on the front end of the bar, which moves through the arc of a circle.

e. The reel.

f. Pulleys which transmit by a belt the rotary motion of the cylinder, *d*, to the reel, *e*, that connected with the reel being the smaller of the two.

g. Friction lever, for tightening or slackening the endless cord, in setting or stopping the winding operation. There is usually a series of such reels in one apartment, driven by the same motive power, but each of them, as has been shown, can be stopped at pleasure. In case the reels are driven by a steam engine, stop-cocks and pipes are so arranged that the water in every basin can be instantly or gradually heated by steam. If desired to run the reel by hand, a handle can be placed upon the shaft of the cylinder, *d*, or of the reel, *e*.

Fig. 8 represents a hand reel, of much the same style as the last, set up and ready for work. This machine was illustrated in the *American Artisan* for February, 1874, in the course of an article by W. V. Andrews, of Brooklyn. It is as good a hand reel as is now in use, though it is made on the same principle as the old French reel of forty years ago.

a. Tin basin with copper bottom for holding the water in which the cocoons are boiled, fitting tightly over the tray, *b*.

b. Square tin tray for reception of cocoons, etc.

c. Short stick inserted in a holder, on which the ends of the cocoons are wound, so as to be ready for use.

e. Cock to let off water from the basin. This should be done every night after use.

f. Door of furnace lined with fire-bricks, wherein the charcoal fire is lighted to heat the water in *a*.

g. Flue-pipe to carry off fumes; this, as supplied, is short, the length and direction in which it may be carried varying in every case. It is necessary that all the charcoal fumes should be carried either into a chimney or into the open air.

h h. Glass eyes on wire holders, through which the threads from the cocoons pass upward to the pulleys at *k*. It is of importance that the glass eyes should be so placed that the threads pass upward in a straight line from the water to the pulleys at *k*, and also from the pulleys to the top of the wheel at *o* (except so far as when diverted laterally by the long guider at *l l*); friction is thus reduced to a minimum, and the elasticity of the thread preserved.

i. A former arrangement for twisting the threads one upon the other; this is now discontinued as unnecessary, since the twist given to the threads at *k* and continued downward to the point *h* effects its purpose with a minimum of friction, and produces a superior thread. This twist is effected by the very simple method of passing one thread round the other, as shown in the small drawing of the pulley, *k*.

k k. Rollers or pulleys revolving on bent wire stands, over which the threads pass.

l l. Porcelain tubes on wire holders, between which the threads pass to reach *o*. Glass eyes may be substituted for the first pair of these tubes with equal advantage.

n n. A grooved arrangement by means of which the long guider working to-and-fro distributes the thread to the reel "in the cross." Unless the thread is thus wound "on the cross," it cannot be unwound at the mills when required to be thrown, and is, therefore, unsalable.

o. The top of the reel on which the silk is wound. One of the arms is furnished with the screw-hinge attached, by means of which the length of the arm is diminished to take off the silk.

p. Handle of the machine. (The letter in the cut is in the wrong place.)

The adult reeler sits on the stool in front of the cocoons, and the other stool is occupied by the child who turns the crank.

FOOD PLANTS.

The traditional food plant of the silkworm is the mulberry (botanical genus *Morus*). There are two species of mulberry indigenous to the United States, namely, the red mulberry (*Morus rubra*) and the small-leaved mulberry (*Morus parvifolia*), neither of which is suitable silkworm food. I have tried in vain to rear the worms upon *rubra*, but they either refuse its leaves entirely or dwindle and soon die upon it. The imported species which are most used are the white (*M. alba*), the *Multicaulis*, and the black (*M. nigra*). This last is inferior to the other two as silkworm food.

The mulberry grows readily, being easily propagated by cuttings or layers or from the seed. The white mulberry, in particular, grows well from cuttings, and this is perhaps the readiest and most economical method of planting to secure a stock.

The cuttings should be started in rows, 3 or 4 inches apart, in ground prepared by deep plowing and harrowing. They should be about 6 inches long, and should be cut just before an eye in every case. They should be almost entirely buried. The quickest way to get a supply of leaves is to grow dwarfs. Set out the young trees from the nursery in rows 10 to 15 feet apart, and 6 to 8 feet between the rows, and form the crown of the tree by cutting down to a foot or so from the ground. The height of the tree and its form are easily regulated by pruning, and upon this process depend not only the vigorous growth of the tree, but also the ease with which the leaves may be gathered when desired. The pruning may be done in February or March, either every year or every other year. All dead twigs and dried bark should be removed and the limbs kept as smooth as possible, as this greatly facilitates picking. The best time for planting is in the fall, from frost until December, and in the spring, from March until May.

For growing standard high trees, a practical raiser gives the following directions: The cutting should remain two years in the nursery without pruning. The third year it is cut down close to the ground and transplanted. The finest shoot is then allowed to grow, and in good land it will reach a height of 8 or 10 feet in one season. The fourth year it is cut back to 6 feet or thereabouts. Then, the three or four terminal buds only being allowed to grow, all others are removed as often as they appear, by passing the hand along the stem.

The *Moretti*, a variety of the white mulberry, is profitably grown in the form of a hedge, and the large size of its leaves makes it a very desirable variety.

OSAGE ORANGE.

The cultivation of the Osage orange (*Maclura aurantiaca*) is so well understood in this country that there is no need of giving detailed instructions on the subject. Very generally used as a hedge plant in those sections of the country which are particularly adapted to silk culture, its leaves may at once be obtained without any special investment of capital. Indeed, as the hedges need trimming, the cutting off of the new year's growth, as the leaves may be wanted for feeding purposes, is a saving rather than an expenditure. Those who use this plant as silkworm food must, however, bear in mind that the shoots from a hedgerow become very vigorous and succulent by the time the worms are in the last age. These more milky and succulent terminal leaves should be thrown aside and not used, as they are apt to induce flaccidity and disease.

In avoiding these more tender leaves, and using only the older and firmer ones, especially when the worms are large, consists the whole secret of the successful rearing of silkworms on this plant; and if care be had in this respect there will be no appreciable difference in the silk crop from Osage orange as compared with that from mulberry.

Should the worms, from whatever cause, hatch before either mulberry or Osage orange leaves can be obtained, they may be quite successfully fed, for a few days, upon well dried lettuce leaves. It will, however, be worse than a waste of time to attempt to feed them entirely on these leaves, or, in fact, on any other plants than the two here recommended.

BENNETT'S GELATINE EMULSION PROCESS.

By W. WAINWRIGHT, JR.*

IN January, 1878, a writer in the "Photographic Almanac" said of gelatine, "that it is equal in value to collodion, we think may be fairly predicated; that it is superior is not yet evident." The same writer goes on to say with collodion "one may digest with excess of silver nitrate for days, and, with due knowledge of the treatment necessary at the after stages, may arrive at a pitch of sensitiveness which is scarcely attainable with gelatine without detriment to other necessary qualities."

Since the article referred to was written, a revolution has taken place with regard to gelatine. Instead of being equal in value to collodion, it is far superior to it in point of sensitiveness, cleanliness of working, exquisite detail, and quickness in developing. This change is owing to the free publication to the public by Mr. Bennett of the proper method of working gelatine—a result at which he arrived after much careful experiment. I do not claim for the negatives and prints I send around to-night that they are the best or the quickest that gelatine can produce. I show them as an amateur, and as examples of what any one may do by following strictly Mr. Bennett's formula.

There are many formulæ of various process published, but it is a question how many of them are workable by ordinary photographers.

As soon as Mr. Bennett had published his formula (and even before, as the process had been shown to many), the market was supplied with gelatine plates by various makers who had never before produced anything like them in rapidity or quality, nor can they now, except they follow his process.

Only the other day it was a matter of speculation whether gelatine plates could be used in the studio. Now many are using them to the entire exclusion of wet plates.

The process claims for itself, I think, the following special peculiarities, the combination of all of which leads to success:

1st. Lengthened emulsification.

2d. Thorough washing, so that all the salts are eliminated.

3d. The power of using a strong alkaline developer without any restraining bromide.

4th. The working in an extra non-actinic light.

The negatives I exhibit are all taken with a rapid rectilinear lens in sunlight. The exposure in April on trees is 15 seconds, and on all the others 7 to 10 seconds, with the exception of one, which is nearly instantaneous. I have not, myself, gone in for very extra rapidity, which would entail emulsifying for from three to five days, but have contented myself for ordinary landscape work with an emulsification of 2½ days, and thorough washing, say 12 hours.

There is little doubt in my mind that owing to the liberality of Mr. Bennett a great impetus has been given to gelatine plates, and the trade and public will much benefit thereby. The formula I use is what Mr. Bennett has already published:

7 grains bromide ammonia.
11 do. silver.
90 do. gelatine.

I send round the prints and negatives together, so that members may be able to compare them together, and they will then see how vigorous and soft a print can be obtained from a comparatively weak negative.

PHOTOGRAPHY IN COLORS.

By M. K. VERSNAEYEN.

MANY people, latterly, have erroneously given to different systems of painting on photography the misplaced title "photography in colors." This was too much to say of the ingenious results, some of which were obtained by the transparence of the photographic image, some by other means. Nay, attempts were even made to make us believe that photographic proofs, tinted by oil or water-colors, were proofs obtained directly in colors. The only process which, up to the present time, has really deserved the name of "photography in colors" is that of M. Ducos du Hauron, but it is only still in infancy, its practice being very difficult, and the colors obtained not always being of the required tone. To arrive at the real colors of nature is no easy task, but we doubt not that M. Ducos du Hauron will, sooner or later, solve this difficult problem.

M. Germeuil Bonnaud's process of photographing in colors—we use this term intentionally, because it is the only term strictly applicable—simply consists in causing the photographic action to operate directly on the color. To this end M. Germeuil Bonnaud has carefully sought the means of rendering a neutral color sensitive, and at the same time insoluble, so that it might be able to resist the numerous baths necessary to the photographic process. When this process is used, all the operations remain the same as in the ordinary method, with this great advantage, that the impressions made by the silver salts on the colored background give precisely the effect of the original model, and have not that hardness of tone that generally characterizes a "retouched" photograph. The print comes out of the bath completely colored. Thanks to the chemical agents and the sensitive paper used by M. Germeuil Bonnaud, the colors and the photograph are henceforward indelibly united. But, in addition to the great artistic results, the material advantages of this discovery are very considerable. Firstly, the true harmony of color is restored, while prints colored by any of the old processes—photo-painting, as one might call them—are always monotonous and wanting in durability. By oil painting on the photograph, the employment of water-colors, or even of transparent media, the cost of production was immensely increased. And this was not all, because to obtain really artistic effects it was necessary to employ artists of such a degree of talent as is rarely found in country towns, where one does not find every day a Millais, a Dickinson, or a Nadar. Now the photographer can do it all himself. So much the better for those who are neither painters nor draughtsmen. It appears that the cost of the colored photographs produced by the Germeuil Bonnaud process is very little, if anything, more than the ordinary uncolored ones. So we get at the price of an ordinary carte-de-visite a photograph in unchangeable and unfading colors.

* Read before the Photographic Society of Great Britain.

REMOVING WIRE AND IRON FROM WHEAT BY MAGNETS.

THE removal of wire from the miller's wheat seems suddenly to have expanded into one of the subjects most important to the miller. The bits of wire that are found in the thrashed wheat are a nuisance that can be said to have had its origin about two years ago, as before that time the wire self binders were but comparatively little used. Last season, however, at least 25,000 wire binders were employed by the farmers, principally in the Northwest, and the manufacturers of agricultural machinery are now preparing to sell as many more during the coming season. One Cleveland firm now has on its books orders for over twelve million pounds of the steel wire used by the self binders. This certainly shows something of the magnitude of the business which is expected to be done in wire binders this season. It certainly cannot be denied that the self binders are a vast improvement over the old method of harvesting, and, as such, are likely to be sooner or later adopted by the farmers of the country.

The cost of the wire for binding the wheat ranges from fourteen to forty cents per acre cut, and one machine will cut about sixteen acres of wheat in one day. We can readily see the advantages, to the farmer, of using such a machine, but to the miller, the result of the introduction of the self binders has been injurious in many instances. Small bits of wire find their way through the thrashing machine into the wheat, and, concealed by their specific gravity, into the miller's garners. It may appear strange that these small steel particles should pass through all the cleaning machinery of the mill to the burrs, through these into the meal and bolts, and sometimes through the bolting cloth into the flour and biscuit.

The pieces of wire range in size from a pin head to an inch in length. They are flattened by passing through the burrs, and their edges, when examined through a microscope, are found to be serrated, and, therefore, admirably suited for cutting the bolting cloth to pieces. We have before this enlarged on the evils which such sharp instruments produce, and any further comment or citation is unnecessary. Every miller must see the necessity of providing against an evil which the increased introduction of wire binders will render far more prevalent in the future than it has been in the past.

The presence of wire in the wheat is largely due to the carelessness of farmers in cutting and removing the bands. Although a band cutter is furnished free by the manufacturers to every purchaser of a self binder, either little use is made of the cutter, or its action is very imperfect. The best cutter we have seen is one invented by Mr. R. Hale, of Minneapolis, and shown in Fig. 4. The cut shows the position of the hand of the operator grasping the cutter, who strikes down or perpendicular, with a band held on the left side, which, after being pulled out from the bundle, is taken by the left hand, till sixteen or twenty are so caught, when they are thrown aside to the rear.

Fig 1 shows a section of the supplemental steel jaws, with a wire in them, which are attached to the primary malleable iron jaws by two screws to each.

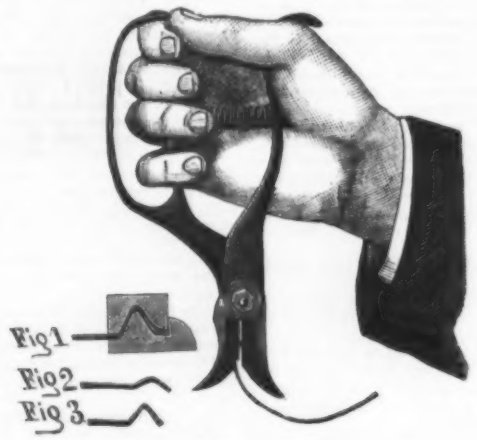


FIG. 4.

FIG. 5.

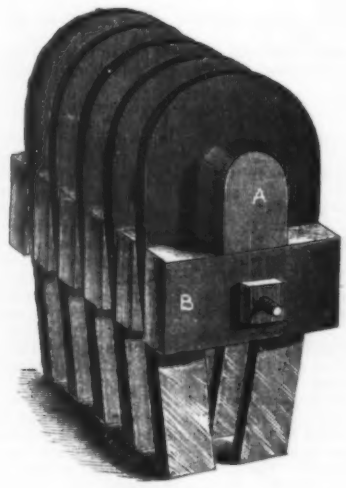


FIG. 6.

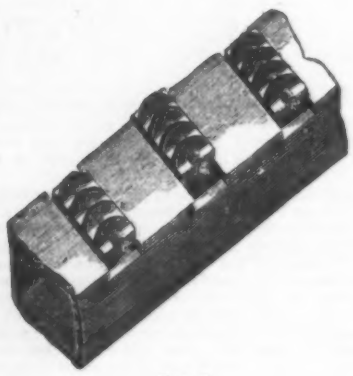


FIG. 7.

FIG. 8.

REMOVING WIRE AND IRON FROM WHEAT BY MAGNETS.

Fig. 2 shows the bend or crimp made before the wire is commenced to be cut, and which prevents the spring of the bundle pulling it out when the cut is finished, or the wire finally parted.

Fig. 3 shows the crimp (which is made before the cut) intensified, when the cut is finished, into a sharp V, making a positive hold, so that the wire cannot be pulled out, unless the operator relaxes his grip, or chooses to let it pass into the thrasher.

If farmers could be persuaded to use the best possible means for removing the wire, united with some degree of care, but little wire would find its way into the mill. Nevertheless, even with the greatest care, the wire will get there, especially if the bands have rusted from exposure. The wheat cleaning machinery will remove many of the bits of wire, and the efficiency of the separators may be increased by making "riffles" straight up and down, on the sieves, in the same manner as employed for taking out gold. But, so far, the most perfect instrumentality that has been employed is the magnet. We have, in former articles, explained how these magnets are used. Their application is simple, and they may be placed in any part of the mill or on any separating machine through which the wheat passes in a stream. One of our illustrations, Fig. 5, shows a grain spout and hopper, with two banks of magnets so placed as to act upon any bits of iron or steel that may be in the wheat, and the other, how the magnets are fastened on the gang. There is, we believe, no patent on this device, and it is already in use in many of the mills of the Northwest, particularly in Minneapolis. Those who have tried the gangs of magnets say that they are very effectual, and tests made with wheat, into which a number of pieces of iron and steel had purposely been put, seemed to establish the fact that the magnets would take out every piece of wire and bit of iron in the wheat passed through the gang. Fig. 6 shows the arrangement of a bank of magnets.

Figs. 7 and 8 represent sections of mill spouts with magnets inserted therein. In Fig. 7 narrow pieces are represented as having been sawed from the upper board, and the magnets bolted together in gangs, with blocks of wood from three-fourths to one inch thick placed between them. This is the form in which the magnets are operated in most of the Minneapolis mills.

Fig. 8 represents the method applied by the millwright of the Humboldt Mill, Minneapolis. Holes barely large enough to admit each leg of the magnets are mortised in the cover of the spout. The magnets are placed in these in diagonal lines, presenting more magnetic surface than when put directly across the spout, as shown in the other cut. Care must be taken, however, not to obstruct the flow of wheat. The top board of the spout is sawed out above and below each series of magnets, as represented by the black lines, and to clear them of wire either section containing a series of magnets is lifted off the spout, the remaining magnets being amply sufficient meantime to catch all iron or steel that comes to them. This plan does away with the bolting of the magnets into gangs, and renders the cleaning of them much more convenient.

By using maple, ash, or other hard wood for the sections of spout cover, through which the holes are mortised, better satisfaction will be attained. After lifting off one of these sections containing a series of magnets, the metal adhering is all carried to the ends of the magnets, by simply drawing them out from the holes in the board, leaving only the extreme ends to be brushed off. Where much metal is observable, it is advisable to clean twice or more each day. When the spout is entirely of wood, it is as well to allow the ends of the magnets just to touch the inside of the bottom, but if the spout is lined with sheet iron, then the magnets must be so suspended that they are at least an eighth of an inch from the lining, otherwise their power is lessened by the sheet iron acting as an armature.

The application of magnets for removing wire showed the necessity for some such contrivance to remove all pieces of iron and steel which, through one cause and another, find their way into the wheat. Not only are pieces of wire found adhering to the gangs when the latter are taken up, but a general assortment of iron scraps, in which nail heads and slivers predominate. One would hardly suspect that such a variety of metallic substances could be concealed in wheat, but the magnet shows that they are there, and they should certainly be removed. Of course, most of these pieces of iron and steel would never reach the burrs, except in cases where their size and shape admitted of their passage through the cleaning machinery. Still, in Europe, where there is no wire in the wheat, from the fact that the self binders can hardly be said to be in use there, magnetic cleaning machines are used for removing such bits of iron and steel as get into the wheat from other causes. At any rate, the experiment costs but a few dollars, and may save a much greater amount.—*American Miller.*

[Continued from SUPPLEMENT No. 168.]

ON THE MINUTE MEASUREMENTS OF MODERN SCIENCE.

By ALFRED M. MAYER.

ARTICLE XIX.

On the Measurements of the Lengths of the Waves of Light; preceded by short accounts of the Undulatory Theory of Light and of the Phenomena of Diffraction and Interference of Light.

WHEN we perceive a distant light it is evident that something, which has come from the light, must have acted on the eye. What is this something? Can experiments on light reveal to us any knowledge as to its nature? How does it come across the space between the eye and the distant light? These are questions which have been asked by thousands ever since men began to think about the mechanism of Nature.

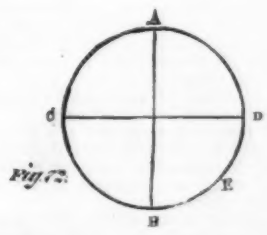


Fig 12.

To give reasonable answers to these questions, some have assumed that the sensation of light is caused by the impact on the eye of very minute and highly elastic bodies, which are shot out from every luminous body in all directions in space. Entering the open eye, these minute bodies strike on the retina, and by their bombardment cause the sensation which we call light. Others have supposed that this sensation is not caused, as just described, by the impacts of innumerable little bodies on the eye, but that the space between the candle and the eye, and the interior of the eye itself, are filled with a very light and highly elastic substance called *ether*. They further suppose that this ether bears the same relation to the distant luminous body that the air bears to a distant sounding bell. In the latter case the quickly succeeding to and fro motions, or tremors, of the bell are imparted to the air which touches it, and these tremors spread through all the surrounding air, somewhat in the manner that water-waves spread around the spot where a stone has been thrown into a quiet pond. Similarly, some suppose that the molecules of a luminous body swing to and fro many millions of times in a second, and that these tremors are given to the ether which surrounds and penetrates the luminous body. These tremors then

spread afar with great rapidity; somewhat in the manner that pulses of sound speed through the air to the distant ear.

We may suppose this and that; but science attempts to get beyond suppositions and guesses, and to form theories from the generalization of facts discovered by experiments and by observations. Now, are there any facts which have been discovered during experiments on rays of light which entirely conform to one of the suppositions we have just mentioned, while these same facts are entirely opposed to the other supposition?

Fig. 73.

There are many facts which can only be explained by the supposition that light is caused by a vibratory motion originating at the luminous body, and sent to the eye through the elastic and rare ether, somewhat in the manner that sound pulses are sent to the ear through the elastic air. Now, these same facts are opposed to the supposition that light is caused by the impacts of very small particles shot out from the source of light. This last supposition, which is untenable, is called the emission theory of light. The other supposition as to the nature of light, which alone conforms to the facts revealed by experiments, is called the undulatory theory of light.

The facts out of which the undulatory theory of light has been woven are very numerous. We can give the reader but a short account of a few of them, and these we will endeavor to present in a way that may lead the student to understand the principal object of this article, which is, to show how the dimensions of the waves of light are measured.

Philosophers discovered the facts on which the undulatory theory rests during their attempts to find out whether, at the place of meeting of rays of light, phenomena took place similar to those which were known to exist at the place of meeting of sonorous vibrations of the air. For a long time it had been well established that the sensation of sound is not caused by the impact on the ear of particles of matter sent from the vibrating body, but is caused by tremors in the air which touches the ear, and that these tremors originated in the vibrations of the body at the source of sound, and were conveyed from this body to the ear by the progressive vibrations of the intervening air. Furthermore, it was a well established fact that two sonorous vibrations could be made to meet in the air, and at their place of meeting cause rest in the air and silence to the ear. This phenomenon, known as the interference of sound, is well shown by experiments on sounds led from a vibrating plate of glass or metal. If you strew sand on the circular plate, Fig. 72, and then, placing your finger at B, draw a violin bow across the edge of the plate at E, just $\frac{1}{5}$ of the circum-

Fig. 74.

ference distant from B, you will see the sand dance along the plate till it reaches the lines, A B and C D, and on these two diameters the sand remains at rest. The sand arranges itself so because in vibrating the plate divides into vibrating quadrants. While one of these quadrants, say A D, in its vibration is moving upwards, the adjoining ones, D B and A C, are moving downwards, and *vice versa*, when the adjoining quadrant, A D, is moving downwards, the adjoining quadrants, D B and A C, are moving upwards. It follows from this that the opposite quadrants, A D and C B, and D B and A C, are moving in the same direction at the same instant of time.

From these peculiar motions of the plate it follows that while the quadrants, A D and C B, are pushing the air away from the plate, A C and D B are causing the air to move toward the plate. Hence a sound pulse sent from A D will always be opposed in its action to a sound pulse sent at the same instant from C B. Now take two India-rubber tubes of the same length, and into an end of each stick a paper cone. The object of the cone is to gather vibrations from the plate and to send them into the tube. Place one of the cones over the quadrant, A D, while the mouth of the other cone is over the quadrant, D B, and join the other ends of the two rubber tubes to the legs of a ≻ shaped metal tube. Now close one ear with soft wax and stick the leg of the ≻ tube in the other ear, while an assistant vibrates the plate so that a quadrant is under the mouth of each paper cone. Although the plate gives a loud sound to your assistant yet you hear nothing, or at least a very faint sound. This is so because while one cone receives a condensed sound pulse, say from the quadrant, A D, the other cone at the same instant receives a rarefied sound pulse from the quadrant, D B. These two pulses travel with the same velocity, and meet at the fork of the ≻ tube, and as the condensed pulse and the rarefied pulse exert equal and opposed atoms on the air in the leg of the ≻, it follows that the air in this part of the apparatus remains at rest, and the ear placed at the open end of this tube hears no sound.

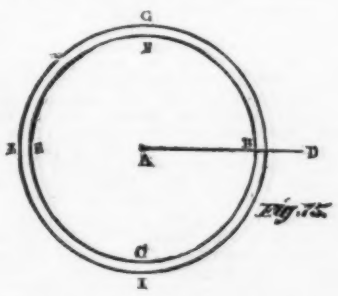


Fig. 75.

The above is one experiment of hundreds in the interference of sound, which show that one series of sonorous vibrations may meet another series of sonorous vibrations and cause silence at their place of meeting.

The knowledge of such curious actions in the case of sounds led philosophers to seek for similar actions in the phenomena of light. That is, they tried to make two beams of light meet and produce darkness. That light added to light may produce darkness is no more extraordinary than that sound meeting sound causes silence. There are many experiments in light which actually give this result, although they are rather difficult of execution, and are rarely seen but by accomplished experimenters. The experiment which is justly considered the most celebrated of all those in the interference of light is that first made by Fresnel, the celebrated French physicist.

He made a sunbeam enter a room horizontally, and to fall upon a cylindrical lens placed vertically. This form of lens causes the beam of light which has passed through it to spread out in the form of a wedge of light, the edge of the wedge being vertical. The rays of this wedge-shaped beam fell upon two plane mirrors, placed vertically, with their planes of reflection so nearly in one plane that they were only inclined to each other by about one-quarter of a degree less than 180°. The rays of light reflected from the mirrors were nearly parallel to each other, and fell upon a distant screen, where they were observed to *interfere;* that is, the surface of the screen which received the light reflected from the two mirrors was not equal in brilliancy to the sum of the intensities of the light reflected from the separate mirrors. Indeed, quite opposite was the effect on the illuminated surface of the screen, for it was crossed by vertical bands of *blackness;* and, moreover, when one of the mirrors was covered so that it could not reflect light to the screen, the black bands disappeared: showing that they corresponded to the *silence* produced by the meeting of two sounds; and, furthermore, when one of the mirrors was covered the illuminated surface of the screen was really

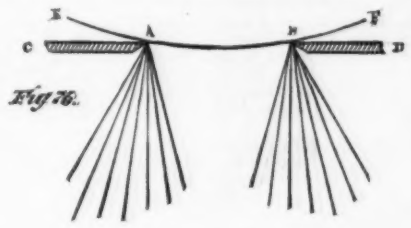


Fig. 76.

brighter than when it received the light at the same time from both mirrors.

To explain how the beams of light reflected from the two mirrors met and produced darkness, we are forced to assume that light, like sound, must consist of undulations or waves sent out into the ether by the luminous body, and that these waves, when they meet under the proper conditions, may neutralize each other's effects and produce darkness; just as the two sonorous waves met and produced silence. To render this clear, imagine two rays of light formed of waves and meeting at L, as is shown in Fig. 73. Here the crest of one wave falls into the crest of the other, and both waves work together, since their vibratory motions are in the same directions at the same time. The consequence is that we have a light at L equal to the sum of the illuminating powers of the two rays. Now, suppose that the two rays meet at O, as shown in Figure 74. Here the crest of one wave meets the trough of the other, and since in these conditions one wave is moving upwards while the other is moving downwards, it follows that these equal and opposed actions exactly balance each other, and therefore at O there will be no motion of the ether, and consequently darkness.

The black bands on the screen were produced by the waves of ether, meeting at those points, being opposed to each other in motion, as in Fig. 74, while the intermediate light bands were made by the rays of light which met at

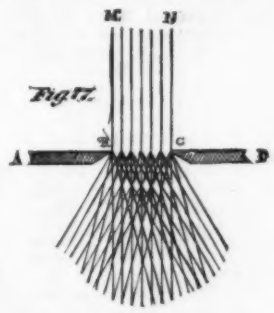


Fig. 77.

those points on the screen having like direction of vibratory motion, as is shown in Fig. 73. The distance from *a* to *b*, Figs. 73 and 74 represents the length of the wave of the vibrating ether, while the distances from *a* to *c*, *c* to *b*, equal half waves. It is, therefore, evident that, if two rays slant from the same vibrating molecule of a luminous body, and meet so that the length of one ray differs from the length of the other ray by a half wave length, these two rays, at the place of meeting, will have opposite and equal motions, will interfere, and produce darkness at that point. The same result will necessarily follow with differences in the lengths of the two rays amounting to a very uneven number of half wave lengths. But if the two rays start from the same vibrating molecule of the luminous body, and meet so that the lengths of these two rays differ by a whole wave length, or by any even number of wave lengths, they will act together at their place of meeting and produce an increase of brightness.

From the above it is evident that if by any means we can cause two rays of light to interfere and produce darkness at a point in space, and then can accurately measure the difference in the lengths of these two rays, measured from their place of meeting to the molecule in the luminous body from which they started, we will have measured a half wave length, or a certain uneven number of half wave lengths of vibrating ether. Or, we may be able to measure the difference in the lengths of two rays which meet and produce the intermediate light band in the interference spectrum. In this case we will have measured a whole wave length, or a certain number of whole wave lengths, in the difference of the lengths of the two rays.

To explain how these measures are made requires a more searching examination of the manner in which waves of light originate, and how they move forward by the successive vibrations of the particles of the elastic ether. We owe to Huygens, the eminent natural philosopher of Holland, who died in 1695, an explanation of the manner in which the waves of ether, causing light, are propagated. It is highly probable that this explanation of Huygens is a true statement of what really exists, for it accounts in the most simple and natural manner for the various phenomena of optics, such as the reflection, refraction, diffraction or in-

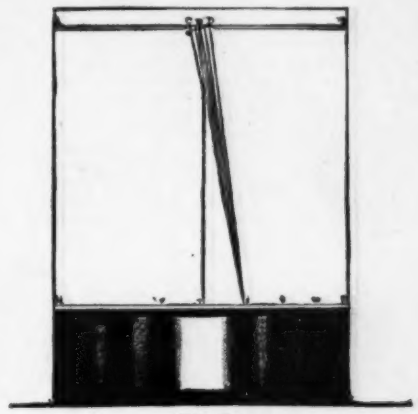


Fig. 78.

flection, interference, double refraction, and the polarization of light. The phenomena of the interference and polarization of light, discovered many years after the death of Huygens, have added to his original conception a wider range and more precision; but, nevertheless, Huygens made the first great step in the direction of the establishment of the undulatory theory of light; and when we consider that he formed these conceptions in 1678, just 200 years ago, we are filled with admiration for his great genius—a genius not only shown in the case of his theory of the actions of ethereal waves, but in his other many remarkable discoveries and mechanical inventions. It is to be hoped that some appreciative and competent person will, some of these days, translate the entire works of Huygens and publish them in English.

The following is Huygens' conception: Imagine at point A, Fig. 75, in the ether, were agitations of sufficient frequency in a second to originate vibratory motions in the ether. This vibratory motion communicates itself to all of

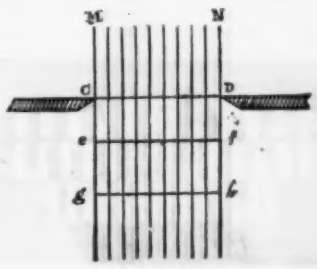


Fig. 79.

the particles or molecules surrounding the point, A, and each of these molecules acts as though it were the particle at A which originated the vibrations. That is, each of these particles acts as a center of disturbance on all those which surround it. Thus the vibratory motions of the particle at A are repeated by all the ether particles as far as they extend in space. If we regard a line of particles, like A D, Fig. 75, extending outwards as a radius from the source of light, A, it is evident that each ethereal particle on this line begins its vibration a little later than did the adjoining particle which is nearer to A; but all of the particles on the line, A D, repeat the exact motion of the particle at A, with all of its characteristics, and each particle tends to spread its own motion to all of the particles which are around it. Conceive that the agitation, originating at A, has entended as far as the circle (or, rather, spherical surface), B C E F, then each particle in this spherical surface, B C E F, will give up its motion to the contiguous particles forming another and an outer spherical shell, G H I L, and so on, each shell of particles receiving its vibratory motion from an inner shell of vibrating particles and giving up the motion thus received to an outer shell of particles; and this giving out and receiving of vibrations continues as long as the agitations of the particles of ether at A supply these vibrations. As we have stated, each particle acts as a center of vibration, just as the particle at A acts on surrounding particles; but the backward action (*i. e*, the action towards A) in a shell of vibrating particles is prevented by the transfer of motion from the next inner

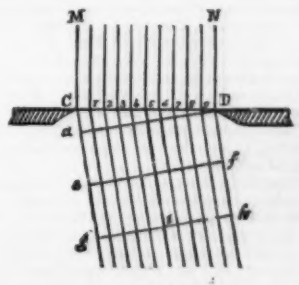


Fig. 80.

shell of particles, while the side actions of the vibrating particles in any shell are prevented by equal and opposing lateral vibratory actions in that shell; therefore, the vibrations can only move forwards and outwards; *i. e.*, in the direction of radii of the sphere.

It is now in order to explain what happens when a wave front—as a shell of particles, all having the same phase of

vibration, is called—meets an obstacle in its onward progress, or passes through an aperture in a screen.

Let A B, Fig. 76, be an aperture in a screen, C D. Let E F be the front of a wave of light which in its progress has just struck the screen, C D, and has passed into the aperture, A B. The side action of the vibrating particles of ether at and near the edges, A and B, of the aperture, meet no longer with any opposition to their lateral action, on account of the removal of the side actions of the vibrations of the particles in the wave front from B to F, and from A to E, which have been removed by the action of the screen, B D and A C. Hence the particles of ether at and near the edges, A and B, of the aperture act as centers of origin of wave motion and send out light into the main beam of light which has traversed the aperture, and, also, into the spaces to the side of this beam, as shown in the figure. If this divergence or inflection of light from the edges of an aperture in a screen (generally termed the diffraction of light) really exists, then the beam of light which has traversed the aperture will not form on a screen a sharply defined luminous band bounded by sharp shadows, but the shadow bordering this band will appear partly illuminated. Now this penetration of light into the shadow really takes place, as can readily be seen by simple experiment. The same inflection or diffraction of light is seen when a fine bar, like a hair, is placed in the path of a beam of light, for the shadow cast by the hair is seen to be partially illuminated. In these experiments on diffraction it is evidently necessary to experiment on light which emanates from a point or line, such as the focus of a lens of short focal length, or the focus of a cylindrical lens, otherwise you will have penumbræ formed by the sources of illumination having considerable luminous surfaces.

Before the classical researches of Fresnel into the nature of light, it was supposed that the diffraction of light, just described, was due to two actions of the sides of the, aperture or of the opaque body on the rays of light; viz., first, an attractive action of the edges of the aperture, which condensed a film of air on them, and that this film of dense air refracted inwards the rays which grazed the aperture or the edges of an opaque body; secondly, a reflection outwardly of the rays which grazed the sides of the aperture. Thus was explained the radiation of the light observed in the phenomena of diffraction. But neither of these is the true cause of diffraction, for neither the intense heating of the sides of the aperture, which would drive off the condensed air, nor the blackening of the edges of the aperture, which would destroy the reflection of light, has any appreciable action in altering the phenomena of diffraction. But the conception of Huygens, as to the manner of propagation of light by the progressive action of oscillations in a highly rare and elastic medium, explains these phenomena in the most satisfactory manner.

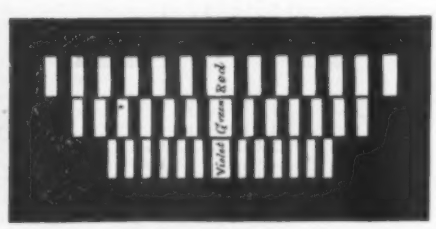


Fig. 81.

Let us now examine what will happen if the aperture be reduced in width till it becomes quite a narrow slit. In Fig. 77, B C is a narrow slit about $\frac{1}{100}$th of an inch in width, made in the screen, A D. A beam of light, M N B C, which, for simplicity of reasoning, we will suppose formed of only red rays, falls on this slit and sets all the particles of ether in B C in the same phase of vibration. Each of those vibrating particles acts as a center of origin of waves, and sends undulations in all directions into the space on the other side of the screen, A B, as is shown by the diverging lines drawn from B C.

If we let these diverging rays fall on a smooth surface of cardboard, placed at a distance of about ten feet from the slit, we will observe an appearance as shown in Fig. 78. In the center of the image, and in a line perpendicular to the center of the slit, C D, is a broad band of white light, bounded by two narrower bands of darkness, and these in turn are flanked by two narrow bands of light, and so on, as shown in the figure. It will be observed, that in going from the center of a luminous band to the center of a dark band, the light gradually fades into darkness, and in going from the center of a dark band to the center of a light band, that the darkness gradually brightens into light. The reader will also notice that the distance between the centers of the two dark bands on each side of the central luminous band is double the distance between the centers of any other contiguous dark bands. The appearance on the screen of these bands, the different degrees of illumination of their parts, and their respective distances from the center of the central white band, can all be explained in a simple manner by the undulatory theory of light.

In the experiment which we have just described, the distance of the screen from the slit is 10 feet, while the width of the slit, C D, is only $\frac{1}{200}$th of an inch. That is to say, the distance of the screen from the slit is 6,000 times the width of the slit. Hence we may consider the rays in any bundle of rays, C D, meeting at a point on the screen, as being parallel to one another.

Let us first consider those rays, which, starting from C D, move parallel to each other and perpendicular to the slit, C D, as shown in Fig. 79. All the particles of ether in C D have the same phase of vibration; that is, they all are moving in the same direction at the same instant of time. From this it follows that any other row of particles of ether parallel to C D, like *e f* or *g h*, will also have the same phase of vibration. Therefore, if at a very great distance from C D, these rays fall upon a screen (as at *r*, in Fig. 78), or if they are brought to a focus on the retina of the eye, they will act together without interference, and produce an intensity of illumination equal to the sum of the illuminations of the rays forming the beam C D, *g h*.

Such perfect accord in action will only take place among those rays perpendicular to C D. Other bundles of parallel rays which start from C D, and proceed at a less angle than 90° with C D, will more or less interfere with one another. Let us consider the case of rays proceeding from C D, Fig. 79, in a direction parallel to each other, but so inclined to C D that a perpendicular let fall from the edge, C, of the slit to the lateral ray D *f*, will make the distance, D *a*, equal to one half wave length of the red rays which have traversed the slit, C D. Then will corresponding points, as *e f*, *g h*, etc., on the two lateral rays of the beam, be in opposite phases of vibratory motion, and will therefore interfere when they meet at a distant point, or on the retina of the eye. The other rays of the beam situate between C *g* and D *h* will only partially interfere, so that the intensity of the light of the whole beam of deflected rays will equal about $\frac{1}{10}$ths of the light given by the reflected beam of Fig. 78.

Now, let us consider a beam of parallel rays deflected so much that the perpendicular, Fig. 80, D *a*, let fall from the edge, C, of the slit on to C *f*, makes C *a* equal to a whole wave length of the red rays. Imagine this beam divided into halves by the ray, 5 *i*. Then the ray C *e* will completely interfere with the ray 5 *i*, when these rays meet on the retina of the eye, because at their point of meeting the ray, C *e*, will differ from 5 *i* by exactly one half of a wave length. The same difference of one-half of a wave will exist between the rays emanating from the points 1 and 6, 2 and 7, 3 and 8, 4 and 9, and similarly for all rays situated symmetrically with reference to the central ray, 5 *i*. Consequently all of the rays of one half of this deflected beam will interfere with symmetrically placed rays of the other half, and the entire effect of this diffracted beam will be zero, and will cause a black band or line at the place where the rays of this beam meet. The first dark band at *s*, Fig. 78, at the side of the central luminous band, is produced by the meeting of rays of a beam so inclined to C D that the perpendicular let fall from D to the lateral ray, C *s*, makes the length, C *a*, equal to one whole wave length. Evidently the same entire interference of rays will occur with diffracted beams in which the distance, C *a*, equals 2, 3, 4, or any number of whole wave lengths of the light traversing the slit.

Now, for the perpendicular, D *a*, to make C *a* equal to two whole wave lengths, it is necessary for the diffracted beam to make double the angle with the perpendicular *m r*, as *m s* did when C *a* equaled only one wave length. Therefore, it follows that the second black band, *t*, will be as far distant from the first band, *s*, as *s* is from the center, *r*, of the central luminous band; and the distance from *t* to *u* will also equal the distance, *r s*. The same spacing of the bands will occur on the left of the central band, *r*. Partially illuminated places midway between these dark bands are produced by the co-operation of rays which differ in their phases of vibration by $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$, etc., or some uneven number of half wave lengths.

In our discussion we have assumed that the rays of light passing through the slit, C D, were those of red light, and therefore all of them have the same wave length. This, however, will be the case only with light which is of one color, or monochromatic, like the light which has passed through the red glass from the windows of mediæval churches, or like that yellow light given out from a flame containing the vapor of sodium. But white light consists of many tints, and if the undulations of ether forming these different tints differ in the lengths of their waves, it must follow that the distance, C *a*, must differ with different colored rays in order that this distance may equal one half wave length of these different rays. The consequence of this will be that the distance separating the dark bands on the screen will vary with the wave length of the light passing through the slit. The longer the wave length, the greater will be the length, C *a*, and hence the greater the deflection of the beam from the perpendicular, *m r*, in order to make C *a* equal to a wave length, and the wider apart must necessarily be the dark bands *s*, *t*, *u*, etc.

These changes in the distances apart of the bands really occur when different-colored lights are allowed to pass through the slit, and they are more widely separated when red rays pass through the slit than when the slit is traversed by green or violet rays. Fig. 81 gives the respective appearances of the spacing of the bands when the slit is traversed by red, green, and violet lights. From this difference in the spacing of the bands made by different colors, it follows that when these differently-colored and differently-spaced bands are all produced at the same time by white light traversing the slit, these differently-spaced bands will overlap, and we will have, as the result, colored bands (known as diffraction spectra), with violet or blue borders on the sides of the bands towards the central light band.

These curious phenomena of the diffraction of light by a fine slit may readily be observed by any one with a lamp and two visiting cards. Cut out of one of the cards a slit about $\frac{1}{10}$th of an inch wide with straight, even borders. Then take a position about 20 feet from a kerosene lamp, with the edge of its flame standing edgeways towards you. Look at the flame through the slit in the card, while you slide the edge of the other card across it till you make the slit in the card quite narrow. You will then see the central bright band of the flame flanked on each side with the colored diffraction bands, or spectra, which we have just described; and if you look successively through red, green, and violet glasses, held between the eye and the slit, you will observe that the bands are separated by the greatest spaces for red light, and become closer when viewed through the green glass, and closest when the violet or blue glass is held before the eye, just as we have depicted in Fig. 81.

(To be continued.)

A NEW KIND OF TELEGRAPH CABLE.

A COMPANY has recently been formed at Cortaillod, in Switzerland, for the purpose of manufacturing a new kind of telegraph cable, the conductor of which is formed of lead and the insulating material of a resinous or sulphurous substance, the whole being covered by a lead tube.

In spite of the slight flexibility of the insulating substance the new form of cable is very pliant, being by no means inferior in this respect to other forms; also the conductor rigorously preserves its central position in spite of any bends which may be made in the cable.

In a recent number of the *Journal Télégraphique*, M. Rothen has given the results of some tests he has made of this form of cable.

Three specimens of this cable were experimented upon, the two first only differing from one another in their respective diameters, the insulating material being of a resinous nature. The third cable had an insulating dielectric of a sulphurous nature.

The lengths, weights, etc., of the cables, were as follows:

	No. 1 cable. Meters.	No. 2 cable. Meters.	No. 3 cable. Meters.
Length	90	110	100
	Millimeters.	Millimeters.	Millimeters.
Diameter of conductor	1·43	1·7	1·7
Exterior diameter of dielectric	2·9	3·7	3·9
Exterior diameter of protecting lead tube	4·8	5·9	6.3
	Kilogrammes.	Kilogrammes.	Kilogrammes
Weight of 100 meters of cable	13·8	20·5	20·9

The cables before being tested were immersed in water for 5 days.

As a standard of comparison, a gutta percha covered copper wire 100 meters long was taken, the diameter of the conductor being 1·4 millimeters and the diameter of the dielectric 4·3 millimeters.

The tests were made with a battery of 150 Daniell cells.

The first tests made were for inductive capacity, the results being as follows:

	No. 1 cable.	No. 2 cable.	No. 3 cable.
Capacity in microfarads per 100 meters	·0184	·0162	·0232

The capacity of the gutta percha wire per 100 meters was ·0237 microfarad.

The insulation resistances of the cables, measured by the ordinary deflection method, were as follows:

	No. 1 cable. Megs.	No. 2 cable. Megs.	No. 3 cable. Megs.
Insulation resistance in Siemens' units per 100 meters.	133,164	162,756	143,028

The resistance of a similar length of the gutta percha wire was 93,708 megs., the temperature of the tank in which the cables were immersed being 19° C.

The conductor tests gave the following results:

	No. 1 cable.	No. 2 cable.	No. 3 cable.
Resistance of conductor in Siemens' units per 100 meters	12·17	7·49	8·21
Temperatures	10·5° C.	9·5° C.	9·5° C.

The resistance of the copper conductor of the gutta percha covered wire per 100 meters, at 19·5° C., was found to be ·97.

If we compare these results by allowing for the varying diameters of the cables, we get the following:

	Insulation resistance.	Inductive capacity.	Conductivity.
Gutta percha cable with upper conductor	1·000	1·000	10·000
No. 1 cable	1·987	·558	·998
No. 2 "	2·208	·540	1·147
No. 3 "	1·817	·826	1·047

These results show that the three cables have an average specific insulation resistance of about double that of gutta percha, while the specific inductive capacity of cables 1 and 2 is rather more than one-half that of gutta percha. The conductivity of the conductor is extremely low, being only about 1-10th that of copper.

MR. FAHRIG, electrician, Southampton, England, has succeeded in producing a new composition for electric lighting, which, when suitably shaped, will burn more brilliantly, give off no smoke, produce little heat, and combustion is slower than in any of the present carbon pencils used. Arrangements are now made for the manufacture of Fahrig's composition light, which can either be made solid or flexible.

SPEED OF A SIGNAL.—Recent experiments prove that a signal sent over the land-line from Paris to Marseilles, a distance of 525 miles, takes 0·024 sec. to travel, whereas a signal sent through the Marseilles-Algiers cable, a length of 574 miles, takes 0·233 sec.

PROF. HUXLEY ON THE LOWEST FORMS OF LIFE.

AT a recent meeting of the Literary and Philosophical Society of Lincoln, Eng., Prof. Huxley delivered a lecture on the lowest forms of life, of which the following is an abstract: In introducing his subject the lecturer said it was one, many parts of which were exceedingly remote from ordinary apprehension, and it therefore became necessary that he should, as far as possible, lead them to the consideration of it by beginning with something which was nearer to them, and something which they could, if they were so minded, study for themselves, and judge whether the statements he had to make to them were correct or otherwise. He had to address them about the simplest and lowest forms of life, and it so happened there were some exceedingly familiar bodies indeed which would serve them very well as an exemplification of those lowest forms, and from which they might start and gradually work their way to those which were remote from ordinary knowledge.

MOULDS.

They were all doubtless familiar with what were commonly known as moulds—those troublesome bodies, very often of a bluish or blackish color, which invaded the pantries of even the best housewives, and covered all sorts of clothing, more especially boots and shoes. The particular kind of mould he wished to speak about was not, however, that with which they would be most familiar; it was another kind of mould, which was distinguished by having a whitish color speckled over with minute dark points, and which was known as mucor; and it was with some brief statement of the results of a careful study of this mucor that he would commence his remarks: upon the structure and the aims of the lowest and the simplest forms of life. They found a series of threads standing up from the surface of the mould, each one of which was terminated by a globular head, as a pin might stand up from a pin-cushion. The bottom part ramified in the material from which the mould was growing, and branched out into a number of fine stems. If they supposed a pin in a cushion, ending where the point should be in a series of branches, that would give them a clear notion of one of these fungi to which the *Mucor mucedo* belonged. The whole of this body was made up of a sheath of the same sort of material as that which constituted ordinary wood. The case was filled with a gelatinous substance, the technical name of which was protoplasm. The protoplasm contained in the pin's head portion of the mucor was broken up into a great number of portions, so that the whole body was a kind of case filled with an immense number of minute particles. Each of these bodies had a diameter of about

the 3,000th part of an inch, and in the larger heads there would, perhaps, be a thousand or two. Supposing that the plant had attained its full development, the wall of the case became extremely brittle, and the slightest touch broke it, when the contents separated from one another, and were carried about by the smallest gust of air, and each particle contained the power of growing into a plant like that from which it started. This little part of protoplasmic matter contained within itself the power, under certain conditions, of going through complicated changes, which would result in its conversion into such a plant like that from which it started; and he would ask them to attend to the precise nature of those conditions, because unless they did they would not understand the part these low organisms played in the economy of nature.

PROTOPLASMS.

Suppose they obtained a little tartar of ammonia, placed it in a vessel of water, dissolved it, and added to it a little of those phosphates used for manures, they would have a pure mineral water, which contained within itself not any one of the chemical compounds that were found in the organisms which he had just described. That was, however, competent to act as the soil in which the mucor would flourish and grow. Now, suppose they took one of these very minute parts of protoplasm and placed it in this water. If the weather happened to be pretty warm, what happened was most extraordinary. It threw out a prolongation on one side, and by-and-by began to throw off one on the other side, and afterwards one in another direction, until at length they had a beautiful star which might be a million times greater than the spore from which it started. Yet this star contained exactly the same nitrogenous composition as the spore itself. Supposing they submitted the water and solution to chemical analysis, they would find that a quantity of tartar of ammonia had disappeared, and that this was exactly counterbalanced by the weight of the fungi which had grown. The marvelous structure which they found took the materials supplied to them, and built them up afresh, until they converted them into substances similar to those of which the largest trees were formed. The whole of the operations went on in the dark just as well as in the light, and they appeared to be entirely dependent upon conditions of temperature. Having assumed the form of a star, by-and-by it ceased growing, but sent up a vertical stem which swelled out to a head, the protoplasm in which split up into minute particles, each of which was surrounded with thin covering. Each of these plants did not take more than eighteen hours to pass through the whole of this process. These minute spores were carried about by the wind until, in a very short time, incalculable millions were spread about. If they grew such a body as this in a bottle, in a similar solution to that which he had described, with a little sugar, the mould came to the top; but if they shook the bottle occasionally, the filaments which made up the star broke up into rounded portions, which gave off buds. By this means they might cause the mucor to assume the form of yeast or barm, and give rise to fermentation. This was a sort of by-product of the plant that gave rise to it. Another process of multiplication was this—when the supply of nutriment became scarce, one of the stems of the stars grew towards another, and the protoplasmic matter became mixed into one common mass, surrounded with a thick coating, and a process of conjugation took place. The whole of this organism started from a minute speck, in which they could see nothing; but the spore which possessed the power of germinating went through a cycle of definite changes, and it possessed the power of manufacturing simple salts into a living body. In addition to this constructive power, it also possessed a destructive power, as, under certain circumstances, the yeast form broke up the substance in contact with it.

DIATOMS.

Prof. Huxley then spoke of the diatoms. He said in any green pool, if they examine the sediment, they would be perfectly certain to find it full of one kind or other of these simple organisms, like a pill-box in shape. The substance of the wall answered to the cell wall of the fungi, and inside it was protoplasmic matter, and in that again there was a mucus. It also underwent a process of conjugation. The fungi must have either animal or vegetable substance to live upon; but a diatom needed nothing but carbonic acid gas, and water, nitrate of ammonia, and some phosphate, and out of these rough materials it had the power of constructing its own body. He then went on to speak of the heteromita, and in regard to monads said by fission the body was split down the middle, and afterwards produced two monads where there was formerly only one. This process went on with such extreme rapidity that it was completed in four or five hours, and under favorable conditions it was perfectly possible that one of these monads might in a few days produce many successors. Speaking of the protogenes, he described them as being merely a structureless protoplasm. They were microscopically structureless, but had the power of moving, feeding, and digesting. These different bodies, minute as they appeared to be, were probably the most important members of the animal and the vegetable world. The organism they had been referring to played a more important part in the economy of nature than all the rest of the animal and vegetable kingdom put together. The fungi were the greatest destroyers of useless matter. Nature did her best to get rid of this matter.

BACTERIA.

Death was said to be one of the causes of putrefaction, but this was not quite true, and it would be more correct to say that life was the cause of putrefaction. If they took proper precautions to keep away from any dead body the organisms he had mentioned it would not putrefy, and the sole cause of that most disagreeable change called putrefaction was the introduction of a particular form of life more analogous to the fungi than anything else, known as bacteria. It was only lately that they had known much about them. The *Bacterium termo* was not more than a 30,000th part of an inch. If they took a small portion of fluid of putrefying matter they would find millions of them in every drop, darting about as if they were fishes. They multiplied with enormous rapidity, and after a certain period of activity passed into a period of rest, and afterwards the protoplasmic substance broke up, and each spore gave rise to a *Bacillus subtilis* again. Their rate of multiplication was so excessively rapid that it needed only one of these bacilli to get into a liquid, and in the course of a couple of days the whole of the liquid would be visibly turbid in consequence of the multiplicity of the bacteria to an extent which no arithmetic could express. The importance of these bodies was that they exerted a fermentative influence, and they did for the fluid what yeast and barm did. It was this fermentative product which gave rise to putrefaction, and if they took such precautions as would keep out the bacteria a dead body would remain intact for an indefinite period. It was on this principle that meats were preserved for an indefinite period by being partly boiled and then hermetically sealed in tins so as to preclude the air getting in. If they considered what would happen if all the animals that died remained where they died until they dried up, they would see what an important part these bacteria played, and if they could all be gathered together they would make more than all the rest of the animal and vegetable kingdom. But they had a great significance which it was important they should all understand.

In France there was an enormous silk industry, but it sometimes was almost annihilated through the death of the silkworms, and that was almost always indisputably caused by fungus. A disease which had all the characteristics of an infectious epidemic resulted in consequence of the germs of the fungi being introduced into the caterpillar, and each one infected became a source of infection, which spread in the same way as infectious diseases were propagated.

There was a splenetic fever known in some countries which killed many cattle, and it had been made out that it was caused by these bacteria. If they inoculated a healthy animal with it, they at once had the symptoms of the splenetic fever.

A new disease had been investigated which was very fatal to pigs, which sometimes became epidemic, and which was caused by bacillus.

CAUSE OF EPIDEMICS.

In vaccine lymph and smallpox there were small minute bodies, and it was found that in these the infection resided, so that they were coming to this conclusion, that the whole of our great epidemics were of the same nature, and if that were correct there could be few forms of life of more importance than those in the limits of the visible, which he had been describing.

In the potato-disease, when it manifested itself, the plant became blackened, and there were cottony filaments on the leaves, and they found, if followed, that they came to a network, which was devouring the tissues of the plant. After the fungus had spread itself through the whole tuber there were stems sent out with the spores, but they did not germinate in the ordinary manner. The spore had the power of locomotion, and it went on until it got some distance, then settled down, and sent out a process plundering cell after cell of the potato. This was multiplied, and the disease spread over a whole field or district. The cause of the disease was at first involved in obscurity, but it was afterwards found to be active spores, which got into the body of the animal or plant and interfered with its life.

[Continued from SUPPLEMENT No. 174, page 2772.]

NATIVE BITUMENS AND THE PITCH LAKE OF TRINIDAD.

By W. O. CROSBY.

ASPHALTUM, usually accompanied by mineral tar and petroleum, occurs at many points on Trinidad and also on the adjacent main. But the largest and most interesting deposit not only of this region but of the world, is that known as Pitch Lake. This is on Point La Brea (La Brea being Spanish for *the pitch*), in the south-western part of the island, and one mile from the Gulf of Paria. The topography of the country about the lake is extremely simple; from three sides—north, west, and south—the land slopes gradually upward from the sea to the surface of the lake, which lies one hundred and thirty-eight feet above the gulf; while on the coast the land is slightly higher than the lake. In other words, the Pitch Lake is on the faintly-marked shoulder of a broad, low ridge which, projecting into the Gulf of Paria, forms the peninsula or promontory of La Brea. Contrary to all topographic laws and precedents, this so-called lake is not in a valley, but on a hill-top. I have already denied the existence, both past and present, of volcanic phenomena in this region, and yet the situation of this remarkable deposit of asphalt is very much as if the broad-mouthed crater of a low-lying volcano were filled to the brim with this material.

I say filled to the brim, because on the three sides named above, the surface of the pitch is even with the brow of the hill, and more so, for at many points the viscous substance is constantly overflowing and moving seaward, after the manner of very sluggish lava streams. The motion is extremely slow, the pitch, where it issues from the lake, being a brittle solid. The moving masses present curved lines and surfaces, which are convex downwards; and Kingsley has very aptly likened these streams of asphalt to glaciers, the lake representing a *mer de glace*. The asphalt becomes harder the longer it is exposed to the air and the sun, through loss of its volatile ingredients, and consequently the down progress of the "black glaciers" must sooner or later be checked, if not entirely stopped. It seems impossible to determine the extent of the overflow, for although the entire slope from the lake to the sea appears as a continuous stratum of pitch, the soil being everywhere very thin or entirely wanting, yet it is probable, as pointed out by Messrs. Wall and Sawkins,* that the most of this superficial sheet has exuded from the asphaltic sandstone—a sandrock supersaturated with asphaltum—which forms the rocky basis of that portion of the ridge where the free asphalt is found. The area covered or underlaid by this mantle of pitch is estimated at 3,000 acres.

The bitumen is certainly not injurious to plant life, for the scanty soil covering the pitch, and consisting largely of that material in a pulverulent state, supports a luxuriant vegetation. The village of La Brea, on the shore, with the boiling houses where the asphalt is refined, rests on the pitch; and the inhabitants complain that their houses are liable to be thrown out of level by the rising or sinking of the tarry foundations. It seems as if everything superficial here, vegetation, houses, roads, etc., must be slowly but surely drifting toward the sea.

"It is fortunate," as one writer has remarked, "that the pitch when compact will not kindle, or in other words will not burn without a wick, for otherwise the entire region, including the village, might suffer the fate of Sodom and Gomorrah."

The pitch not only forms the sea-shore for the greater part of a distance of four miles, but in front of the village it appears from beneath the sea as a solid barrier reef some hundred yards from the shore, which is a source of danger to unwary boatmen when the water is rough. It is probable that this peninsula of La Brea owes its existence to the protection afforded the land by the asphalt, which resists the action of the waves and running water far better than the unconsolidated clays and sands forming the coast to the north and south.

We may now return to the fountain head, the lake. Of the various published descriptions of this remarkable phenomenon, there are very few that can justly lay any claim to accuracy, and strange to say these are not to be found in encyclopedias, nor even in our best text books of science. Probably no object in nature has been so grossly misrepresented as the Pitch Lake of Trinidad. In an official history of the English Exposition of 1851, under the head of descriptions of articles from Trinidad, it is stated that "the Pitch Lake is on the highest land in the island. It is soft and fluid at the center, and there is an active submarine volcano near the coast." I have already given the true altitude of the lake as one hundred and forty feet, while the highest point on the island is Mt. Tucuiche, 3,100 feet above the sea. The submarine volcano is a petroleum spring which comes up under the water a short distance from shore; the water is visibly oily over an area of several rods, and bubbles of gas are sometimes seen to escape, but nothing farther, though another writer speaks of this as "a submarine volcano which at times makes a noise like thunder, and emits naphtha and petroleum." The lake itself is usually described as three miles in circumference, hot and fluid in the center, but cold and solid toward the shore. In point of fact this body of pitch, which is of approximately circular outline, is scarcely one and one-half miles in circuit, and there is no part of its surface that may not be walked upon with impunity. The temperature is uniform throughout. The area of the lake is ninety-nine acres. Its surface, soft enough in a few spots to receive the impression of a man's boot, is for the most part quite hard and firm, and everywhere of a dull earthy-brown or brownish black color. The fracture is eminently conchoidal, but the luster is always dull, the result of an admixture of twenty to thirty per cent. of earthy matter, sand, and clay. These impurities are removed by boiling, and the pitch then becomes shining black and still more brittle.

There are some twenty or more patches on the lake, five to fifteen yards in diameter, where soil has collected and vegetation—trees, shrubs, and grasses—has gained a foothold, forming green islands or oases. The surface presents many small dome-shaped swellings or protuberances, from an inch to a foot in diameter; these pitch bubbles are always hollow, and contain traces of the lighter portions of vegetation in a half decayed state, the thin covering appearing to have been raised by gases given off from the decomposing leaves and twigs, or liberated by the sun's heat from the pitch itself. Excavations made in the pitch show that below the surface these cavities or vesicles are exceedingly numerous; they are usually almond-shaped or ellipsoidal, being flattened by pressure, and though always the result of gaseous expansion, are commonly filled with water; in fact, the entire mass of the pitch is saturated with water; so that even where quite soft it will not soil the hands, because the water oozes out and prevents adhesion. The earthy impurities of the pitch also assist in rendering untrue, in this instance, the old proverb that one cannot touch pitch without being defiled.

The pitch is mined or quarried by excavating areas thirty or forty feet square to a depth of two to four feet. As soon as the work ceases on one of these cellar-like excavations the surrounding asphalt, seeking to restore the equilibrium, begins to obliterate it, the walls not closing in perceptibly but the bottom rising up, and in a few days no trace of the opening remains. This is only one of many indications of greater fluidity below the surface. The plasticity of the pitch is evidently due to the oily matter which it contains, and not in any sensible degree to the temperature. Hardened bitumen, it is true, may be fused by the application of sufficient heat, but that which is naturally fluid remains so at all ordinary temperatures. As already explained, when the asphalt is exposed to the air it becomes solid through loss of its volatile ingredients. Towards the center of the lake are several detached areas, a rod or two in breadth, which are softer than the rest of the surface, and yield under the feet, "so that on standing a few minutes one feels that he is gradually settling down, and in the course of ten or fifteen minutes he may find himself ankle deep." "But," as Mr. Manross* truly says, "in no place is it possible to form those bowl-like depressions round the observer described by former travelers." Nor is it possible that Kingsley is right in saying "no doubt there are spots where, if a man stayed long enough, he would be slowly and horribly ingulfed." The inferior density of the human body would prevent its submergence even if the pitch were quite fluid.

In the vicinity of these places many small streams of gas escape from the pitch. The evil smell and the deposit of sulphur left on the pitch tell us that the gas is chiefly sulphureted hydrogen; but the sulphurous odor ceases to be perceptible at a distance of a few rods, and does not extend for ten or twelve miles, as some writers have asserted.

The surface of the lake does not present a continuous sheet of asphalt, but is traversed by a net-work of channels in which the rain-water collects. These anastomose and divide most curiously, forming one connected system, and dividing the pitch into numerous flat-topped or slightly convex areas or islands which are usually of quite irregular outline, though sometimes nearly circular, and from ten to one hundred feet in diameter. A piece of marbled paper would make an excellent map of the lake. The sides of the channels are always convex, presenting curves of great regularity and beauty; and when three or four channels meet, a star-shaped depression is formed. Canon Kingsley† says, "Conceive a crowd of mushrooms, of all shapes, from ten to fifty feet across, close together side by side, their tops being kept at exactly the same level, their rounded rims squeezed tight against each other; then conceive water poured on them so as to fill the parting seams. Thus would each mushroom represent, tolerably well, one of the innumerable flat asphalt bosses which seem to have sprung up, each from a separate center, while the parting seams would be of much the same shape as those in the asphalt, broad and shallow atop, and rolling downward in a smooth curve till they are, at bottom, mere cracks from two to ten feet deep. Whether these cracks actually close up below, and the two contiguous masses of pitch become one, cannot be seen. As far as the eye goes down they are two, though pressed close to each other," the hard exteriors of the masses preventing them from coalescing.

The water filling the channels is clear, pure rain-water, and contains numbers of small fishes, water beetles, and other aquatic animals. It has been observed escaping from the canals at eight nearly equidistant points on the circumference of the lake.

Several hypotheses have been proposed to account for the

* Report on the Geology of Trinidad.

* "American Journal of Science," 1855.

† "At Last: A Christmas in the West Indies."

peculiar structure of the lake. Mr. Manross says: "The channels are produced and maintained by the following singular process: Each of the many hundred areas into which the lake is divided possesses an independent revolving motion in this wise: In the center of the area the pitch is constantly rising up *en masse*, displacing that which previously occupied the center, and forcing it toward the circumference. The surface becomes covered with concentric wrinkles, and the interior structure somewhat laminated. Where the edge of such an expanding area meets that of the adjoining one, the pitch rolls under, to be thrown up again in the center at some future period. It is difficult to conceive of a motion like this going on in a material almost of stony hardness, but that such a revolution is constantly taking place over the entire surface of this black lake cannot be doubted. The conclusion then to which a close observation leads us in regard to the present condition of this singular lake is, not that it had suddenly cooled down from a boiling state, as heretofore described, but that solid as the material is, it is still boiling, although with an indefinitely slow motion. As the descent of the glaciers may be considered the slowest instance of flowing in nature, so the revolutions of the scarcely less solid bitumen of this lake may be set down as the slowest example of ebullition."

Messrs. Wall and Sawkins, on the contrary, deny the existence of the revolving motion, and consider that each of the areas represents a center of emission where the asphalt has issued from the underlying sandstone, "and gradually advanced until the material from the surrounding foci being encountered, further progression was impeded, and the accumulation proceeded in the vertical in place of the horizontal direction." But the present level of the lake has evidently been maintained for ages, and consequently it is difficult to see why, if this view is correct, the asphaltic bosses have not flattened out and closed up the water channels.

Neither of these views can be regarded as entirely satisfactory. Mr. Manross is undoubtedly right as regards the circulation, though in error as to its cause. He finds unique and conclusive evidence of the revolving process in "numerous pieces of wood, which being involved in the pitch are constantly coming to the surface. They are often several feet in length and five or six inches in diameter. On reaching the surface they generally assume an upright position, one end being detained in the pitch while the other is elevated by the lifting of the middle. They may be seen at frequent intervals all over the lake, standing up to the height of two or even three feet. They look like stumps of trees protruding through the pitch, but their *parvenu* character is curiously betrayed by a ragged cap of pitch which invariably covers the top and hangs down like hounds' ears on either side." These fragments of wood are of the same recent origin as the leaves and twigs contained in the vesicles of the pitch. From the surrounding forest or the green islands of the lake itself, they have found their way into the water channels, become water-logged, sunk to the bottom, and been drawn down by the ever-revolving pitch.

In one case at least within my observation, a recently detached portion of one of the islands of vegetation afforded incontestable evidence of a horizontal movement of the subjacent pitch to the extent of several feet.

According to the present writer, the true cause of the revolving motion of the pitch, and of the structure resulting therefrom, is found in a fact pointed out by Wall and Sawkins, but not insisted upon or fully appreciated by them, viz., the great diurnal range in the temperature of the surface of the pitch. On unclouded days the asphalt attains an average temperature of about 140° Fahr., and sinks during the night to 70° or 60°, suffering a variation of 70° to 80°, which must produce a considerable change of volume, especially if we consider the vesicular nature of the pitch, and the quantity of water which it contains. This expansion will be superficial, and its chief tendency to extend the pitch horizontally. Where the pitch is covered by water it will not experience this alteration of volume. The courses of the water channels may have been determined originally by slight inequalities of the surface, holding shallow sheets of water, or drifting sand may have occupied these positions and served to protect the asphalt along these lines from the heat of the sun. The main point is that the protected areas would be forced downwards by the expansion of the unprotected areas, and this motion once established would continue without interruption until the contours of the present surface was developed.

Nocturnal radiation and consequent contraction could not undo the effect of the diurnal expansion, but the equilibrium would be and doubtless is maintained by the elevation of pitch from below in the center of the areas. The plastic pitch beneath the solid crust is sometimes forced upward through the crevices in the bottom of the channels. One interesting example of this is described by Mr. Manross: "In one of the star-shaped pools of water, some five feet deep, a column of pitch had been forced perpendicularly up from the bottom. On reaching the surface of the water it had expanded into a sort of center-table about four feet in diameter, but without touching the sides of the pool. The stem was about a foot in diameter. I leaped out upon this table and found that it not only sustained my weight but the elasticity of the stem enabled me to rock it from side to side. Pieces torn from the edge of this table sink rapidly, showing that it had been raised by pressure, and not by its buoyancy."

No soundings have ever been made in this lake, and its depth is unknown. The thickness of the deposit is of course a factor of the first importance in determining whether the supply of asphalt from this vicinity is likely to prove practically inexhaustible in view of the steadily increasing demand for this material in the arts. According to Wall and Sawkins each foot in depth is equivalent to 158,400 tons, and they assume the maximum average depth at thirty feet, making the total supply 4,752,000 tons. Judging by the uniformity of the asphalt and the size of the revolving areas the true mean depth must considerably exceed this estimate. It is believed that the pitch could be readily excavated to a depth of ten or fifteen feet, and from that level iron bars could probably be forced to the bottom, and the true depth accurately ascertained. In considering the question of the probable permanence of the supply, it is important to remember that the material is doubtless still escaping from the underlying asphaltic sandstone, though perhaps very slowly

As regards its origin, the lake is believed not to differ essentially from any of the patches of pitch scattered over the surrounding country except in this, that the form of the surface has been more favorable for its accumulation. It appears to be simply a large puddle of pitch, which has oozed out of the sandstone and collected in a basin-like depression in that rock.

The observations of Mr. Wall have placed the vegetable origin of this bitumen beyond question. The asphaltic sandrock is rich in vegetable remains, and it is possible to trace every step in the conversion of these into asphaltum, until the organic texture of the wood is entirely obliterated and pure bitumen results, the external form of the wood alone remaining.

The fact that the Island of Trinidad lies between a portion of the delta of the Orinoco and the sea, long ago led Sir Charles Lyell to adopt the view that the asphalt deposits of Trinidad, including the Pitch Lake, which is on the side of the Island towards the delta, represented the drift wood brought down by the Orinoco in past geological ages. But I believe he afterwards concluded that this explanation, like the wood itself, was rather far-fetched. For it can be proved that at the time (Miocene period) when these asphaltic beds were forming, the mouth of the Orinoco was some one hundred and fifty or two hundred miles further up stream than at present.

A RECENT VISIT TO VESUVIUS.

MR. H. D. GARRISON writes as follows to the Chicago *Pharmacist:*

One of the most interesting suburbs of Naples is Puzzuoli and its environs. Here we saw the crater of a nearly extinct volcano called "Solfatara." The crater is elevated about 500 feet above the sea, and is about 100 feet deep by 500 feet in breadth. Most of the floor of the crater is covered with shrubs and young trees, but at the southern side the ground is found to be very hot, and from a kind of cavern in the wall at this point, steam, mixed with carbonic, hydrochloric, and hydrosulphuric acid gases, issues in large volumes with a noise resembling that of the escape of steam from the safety valve of a large steam boiler. Near this point a heavy stamp of the foot, or better, a blow by throwing down a bowlder of considerable size, causes a peculiar hollow sound and trembling of the floor, which tell you most emphatically that you are standing over an immense cavity. As the earth on which we stood to make this experiment was hot enough to broil a beefsteak, we concluded that if the floor were to cave in we should reach Dante's Inferno at once. Besides the main opening, steam was whistling from a score of minor vents, around all of which sulphur in apparently a pulverulent form, but really in prismatic crystals of the size of those of quinine, was sufficiently abundant to attract attention, but not to pay for collection. The lava walls of the crater, wherever acted upon by the acid steam, were covered to the depth of about two inches with an inflorescence of white, acid, saline matter, probably chiefly sulphates and chlorides of calcium, aluminum, etc.

At the distance of about a mile from Solfatara we visited another crater of similar appearance and size. In this case the bottom of the crater was almost perfectly level, because until recently it had been partly filled with water, constituting a small lake, "lago d'aguano." At one side of this crater, as at Solfatara, steam in small quantities still issues, and the floor is not only very hot, but so exceedingly thin that the sound and trembling caused by ordinary footsteps were truly alarming. The same inflorescence of sulphur and salts seen at Solfatara was seen here in abundance. It is worthy of note that these nearly extinct volcanoes six miles *north* of Naples, and Vesuvius ten miles *south* of the city, seem to be connected, for when Vesuvius is most active these are nearly silent, and *vice versa*. A similar connection is believed to exist between Vesuvius and Mount Etna, over a hundred miles south, in the Island of Sicily.

A short distance from the steam jets last mentioned, and in the wall of the same crater, is a small cavern, the "grotta d'ammoniaca," from the rear wall and floor of which nearly pure carbonic acid gas in great quantity issues, forming a pool, so to speak, about two feet deep. Notwithstanding the name, I could not detect a trace of ammoniacal gas, which if present would not only have made itself recognized by its odor, but by forming vast quantities of carbonate of ammonia. I think this gas is mixed with a trace of hydrochloric acid gas, which, by its pungency, has deceived the Italian savants. A short distance from the last named grotto is the famous *Grotta del Cane*. This is a kind of tunnel-shaped cavern in the wall or hill surrounding the crater. It is about five feet wide by eight or nine feet high, and extends perhaps forty feet into the hill, dipping downward at an angle of about twenty degrees. It is filled to a level with the external opening with nearly pure carbonic acid gas. One can wade into this gas just as in water, first ankle deep, then knee deep, then waist deep, and finally over the head. A lighted match, or even a large torch, is extinguished at the surface of the gas very promptly. Although we demurred to the experiment, a strong dog was hustled by a burly Italian into the gas and held there for about half a minute, when he fell down, and on being carried out was so far asphyxiated that his case for some time appeared doubtful. I was astonished to observe how extremely livid his tongue and lips became in so short a time. A number of dogs are kept for the repetition of this experiment, so interesting to those not fully acquainted with the toxicological properties of carbonic acid gas. Some of these dogs have become so sagacious that on being taken into the gas they at once fall down and struggle as if dying, knowing that on the appearance of these symptoms they will be taken out and thus escape further torture. Such strategy on the part of a man would be attributed to *reason*, but in the case of a dog is only ranked as the effect of *instinct*.

Just as at Niagara Falls, so here in Italy; around every object of interest there is a cordon of swindling traps, which the most wary traveler cannot escape. The amounts you *must* pay are not usually grievously high, but the incessant and impertinent clamoring for more, *more*, MORE, makes sight-seeing almost a nuisance rather than a pleasure. If you accede to one extortionate claim, just to get rid of the fellow, he at once conjures up a still greater one, and presses it upon you with all the zeal that arises from a recent victory and a knowledge of your weakness.

ASCENT OF VESUVIUS.

Having waited several days for a perfectly clear morning, we were at length rewarded with a delightful day, the only one we have seen in three weeks. At 9 o'clock, in a three-horse carriage, we set out for the base of the cone. Two and one-half hours, mostly spent in zigzag driving up the gentle slope of the mountain, through immense black lava fields, brought us to a little plateau, on which is situated a house called the "observatory," from which the anxious Neapolitans, by the aid of Prof. Palmieri, watch the behavior of the fickle volcano. A mile farther of winding path through and over lava streams brought us to the base of the cone, where the ascent begins in good earnest. If the reader will imagine a gently sloping mountain two thousand feet high, on the summit of which stands a cone of black ashes mixed with slag-like crags and masses of lava also two thousand feet high, and from the summit of which vast clouds of steam continually escape, he will have as accurate a notion as one can have of this mountain without seeing it. The ashes of which this immense cone is chiefly composed much resemble the ashes and cinders taken from the ash-pit of a bituminous coal burning steam boiler.

Our party consisted of two ladies and three gentlemen. One of the gentlemen being lame, was carried up to the crater in a sedan chair by four burly Italians. For each lady two aids were employed, one to go ahead and pull her by a small rope held in her hand or passed around her waist, and the other to follow and push. We able-bodied gentlemen, thinking ourselves as strong at least as an Italian, determined to climb up unaided, except by the use of a staff or huge cane. Having dispersed the throng of lazzaroni which gathered about me, I began the ascent, only accompanied by two young Italian boys whom I could not scare away. When about one-third of the way up I concluded that perhaps, after all, I could never procure so much aid and comfort for so little money, and accordingly engaged the little rascals to help me. From that moment my predicament became ludicrous, with one of the little cubs tugging at me in front, while the other at least pretended to push me from the rear. Between the spasmodic jerking and pushing, and the slipping and rolling of stones under my feet, I often found myself unable to maintain an erect attitude, or an amiable style of conversation.

After two hours of unremitting toil we reached the summit, where the grand view which greeted us made us at once forget the severe labor we had incurred to attain it. As we neared the top the wind became biting cold, although in the valley the air was rather uncomfortably warm.

The crater is a large, saucer-shaped cavity, somewhat elliptical in shape, about 500 feet wide by 700 feet long, and about 100 feet deep. At one side the rim of the crater was wanting for a space of about 200 feet, and through this gap the last great river of lava had apparently run. The floor of the crater consists of immense black wads and rolls of lava contorted and twisted into every possible shape. Within the main crater, but somewhat to one side, arises an interior or secondary cone, about sixty feet high, from which the present tame eruption is proceeding From an opening apparently about twenty feet in diameter, at the summit of this little cone, steam and melted lava escape continuously. The steam mounts up in immense clouds, while the lava, in the form of a little river about ten feet wide, flows slowly over the main floor of the crater, its course being determined by the existing inequalities of the floor. As the lava stream often shifts its course, it happened that we were able on this occasion to walk over what had been the river a few days before. In the great gaps and chasms beneath our feet the lava was still red-hot, and so soft that I thrust a strong stick down into it fully three feet. Men were hauling out wads of it, which they pressed by iron moulds into medallions of King Humbert, Queen Victoria, etc. At intervals of about a minute explosions occur, by which the steam and melted lava are projected upward to heights varying from twenty-five to one hundred and fifty feet, the lava, falling back in great red-hot wads, half rolls and half flows down the small cone. The noise occasioned by one of the more severe explosions is similar to the report produced in blasting in stone quarries, or to the explosion of a small steam boiler. It seems incredible that we should be able to walk over lava which, at a depth of twelve inches below our feet was red-hot and semi-liquid, but the explanation of the fact is found in the circumstance that lava is a very poor conductor of heat. Aside from the main exit, steam and acid gases issue from hundreds of small cracks and fissures, around which an inflorescence of sulphur in the form of minute prismatic crystals is very conspicuous.

The descent of the cone is very easy, and can be made in about ten minutes. In fact, one can run with the speed of a deer down the great ash pile, sinking ankle and sometimes knee deep in the loose, coarse dirt called ashes. Indeed, it is difficult to avoid running, and having begun it is very difficult to avoid running rapidly, and then almost impossible to stop. As I was slowly plodding down I heard a sound in the rear like "krant," and a second later a friend shot by like an arrow, and thus continued about 200 yards before he could effect a halt. He had tried running "just to see how it would go," and could not stop. I had tried the same experiment a little before with even worse success, for when at full speed my feet became so deeply immersed in the loose ashes that I was unable to make them go as fast as the upper portion of my body. The result was in strict accordance with the well-known laws of moving, and especially of falling bodies.

GLAZED FROST.

THE cold and severe winter we have experienced has been the cause of many disastrous accidents, where loss of life and property has been far beyond the average. Its very severity has, however, been the means of throwing interesting light upon physical phenomena of a very rare and uncommon nature, and science has fortunately been able to glean, from the registered facts, some slight compensation for the general harm inflicted. The peculiar glazed frost that covered the neighborhood of Paris, from the 23d to the 25th of January, awoke the attention of French *savants*. Numerous observations were registered by competent and trustworthy men, and Professor Jamin, in an article published in the *Revue des Deux Mondes* of the 15th of February, not only recalls the date referring to the phenomena we allude to, but further offers explanations, based on purely scientific principles, that afford complete satisfaction. Our object is to submit M. Jamin's conclusions to our readers' appreciation.

The unprecedented glazed frost (*verglas*) that covered a large portion of France at the time we have mentioned caused immense havoc and destruction in the country round Paris, and more especially in the large and beautiful forest of Fontainebleau. The French papers were at the time full of these disasters, and their description appeared hardly credible to those who had not witnessed the facts alluded to. Large trees were spoken of as having been felled to the ground by the weight of accumulated ice without the intervention of either wind or stormy weather. Telegraph posts were overturned, the wires broken, and for several days telegraphic communication became most irregular throughout France. Estimates were soon forthcoming to show that, far from being exaggerated, the descriptions contained in the daily papers hardly conveyed a correct idea of the extent of harm done; 150,000 cubic meters of wood were brought to the ground in the forest of Fontainebleau alone, and of the young trees of Villefermoy from 60 to 80 per cent. were broken or utterly destroyed.

During the preceding weeks large quantities of snow had fallen, sweeping from the atmosphere the germs, dust, and other impurities it commonly contains. The air was there-

fore unusually pure. We shall see how this circumstance holds a prominent place in M. Jamin's theory.

On the morning of the 23d the thermometer marked 4 deg. below zero (Centigrade). The weather was perfectly calm and not a breath of air stirring, when a thin and vertical rain began to fall. Notwithstanding the temperature being at 4 deg. below freezing point, the rain fell perfectly liquid, and entirely free from any particles of ice. This continued for two days without any change in the circumstances just mentioned. The rain was, however, instantaneously frozen on touching the ground, so that every exposed object was rapidly covered by a coating of ice. In many cases the crust was quite out of proportion with the supporting body. Telegraph wires were enveloped in cylinders that measured from 2 in. to 3 in., and leaves were covered by crusts of ice of more than an inch in thickness. Where trees grew together the ice that accumulated on their entangled branches and leaves gradually became a solid mass, that weighed heavily on its fragile support. A branch of rhododendron, weighing 13 grammes, was found to support 330 grammes of ice. The telegraph wires had to support fifteen times their own weight.

The silence of perfectly calm weather was soon interrupted by the crashing noise of falling trees and branches. All had to give way under the gradually accumulated masses of ice. At Fontainebleau some of the largest trees were unable to resist the heavy pressure. An oak tree measuring 7 ft. in circumference was broken off at 12 ft. from the soil and hurled to the ground. Never did so much destruction come by so unexpected a means.

Nor were living beings altogether spared. Birds were found fixed to the ground in a coating of ice. They were in an upright position, and had evidently been caught instantaneously in a sheet of ice. The rain as it fell upon them was frozen, hindered their movements, and, once motionless, the coating rapidly grew thicker. M. Jamin remarks that the large animal remains of past geological epochs, formed on the borders of the Lena River, in a perfect state of preservation, were probably caught and fixed in a bed of ice by a similar process.

It is a well-known fact that, if due precautions are taken, water can be preserved liquid at a temperature of several degrees below freezing point. Fahrenheit, Blagden, and Gay-Lussac made many successful experiments, and at a more recent date Despretz was able to attain a temperature of 20 deg. below zero without the formation of any ice. A vibration, however slight, or the contact of anything solid, and especially of a particle of ice, is sufficient, under these circumstances, to freeze the water in an instantaneous manner.

When ice is heated it melts more or less rapidly according to the temperature applied, but in no case does it suddenly become liquid. The operation is invariably gradual, and to the last, whatever may be the surrounding temperature, the remaining ice is constantly at freezing point. This phenomenon was a puzzle for natural philosophers, and what became, it was asked, of the heat applied? It gave rise to the theory of latent heat, by which it was considered that the change from solid to liquid demanded a mechanical effort represented by the heat absorbed. To transform ice into water, it is therefore necessary to furnish a given amount of latent heat, which has to be taken away again, when the change from water to ice has to be achieved. Water can be frozen in two different ways, the choice of which is regulated by outward conditions alone. By the first method water at once loses a portion of its latent heat; ice is formed gradually, and the remaining water keeps at the temperature of freezing point. In the second case the latent heat is not in any way lost at first, and as the temperature is lowered so does the water get colder without losing its liquid form. The greater the precautions taken the lower the temperature can be carried. The total amount of water is then instantly congealed, and however low the temperature may have been, the ice that is formed rises at once to freezing point. The experiments we allude to above refer to this possibility of lowering the water's temperature, under certain appropriate conditions, without depriving it of any portion of its latent heat. We shall now attempt to apply these theoretical principles of natural philosophy to the phenomena we have described as occurring over so large a portion of France.

Glazed frost is produced under several different circumstances. Snow that is slightly melted on the surface may suddenly freeze and give rise to a superficial coating of ice. Abundant dew, when frozen, may also cover the ground with a film of ice. And, lastly, something similar happens when, after very cold weather, the wind suddenly changes and the temperature rises. A slight drizzling moist or rain invariably commences, that is at first frozen by the contact of the cold soil. But none of these glazed frosts ever produce anything beyond a thin coating, that seldom lasts. Very little connection can, therefore, be found between them and the extensive glazed frost of January. We must search for a totally different origin.

De Saussure was the first to remark that the Alpine fogs could stand very low temperatures without congealing. The same has since been observed in northern climates. Nor, were it otherwise, should we ever see fogs in cold weather. M. Fournet, of the faculty of Lyons, asserts that they seldom freeze before attaining —14 or —15 deg. Centigrade. The small liquid globules of which fogs are composed are then frozen, either into small solid needles or into a frost smoke. It is probable that the very division of the water into small globules is a favorable circumstance, and assists it, in a great measure, to keep its latent heat so long and remain liquid.

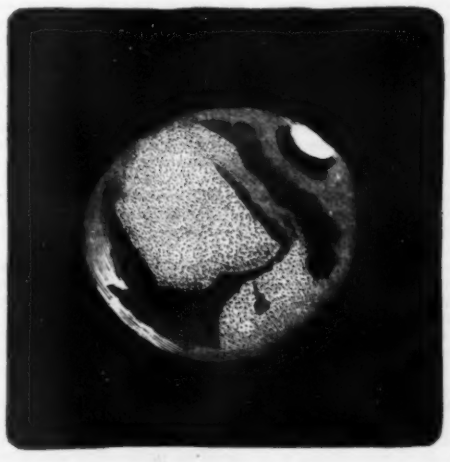
There is no reason why rain should not do the same if placed in the favorable conditions required. Although the water is here less divided than in the case of fogs, we have seen what results have been obtained in laboratory experiments. We know that when all is kept still and quiet, when contact with solid bodies, and, above all, with ice, is avoided, the temperature of water can be lowered without any ice being formed. We may add that uniform movement is no obstacle, for Blagden was able to run out water gently at a low temperature without altering its liquid state. Messrs. Masse and Godefroy, who studied the Fontainebleau frost, may therefore assert, with every reason, that what they were able to observe was simply an uncommon illustration, by nature, of what had often been studied experimentally by natural philosophers. The atmospheric conditions we referred to in the commencement of this article were most appropriate. The air, as we have already seen, was not only calm, but what is more important, was clean and free from the solid particles it usually contains. The rain was able to fall, not only quietly, but also without coming in contact with anything solid. It kept its liquid form, precisely as a winter fog and as laboratory water can keep liquid, and preserve their latent heat for several degrees below freezing point. But why, it may be said, can this phenomenon be so seldom observed? It stands to reason that M. Jamin's theory being based upon the excessive purity of the air at the time the rain fell, the special circumstances required can only be repeated at very rare intervals. They have never before, we may safely say, attracted the same attention or spirit of inquiry.—*Engineering.*

ANOTHER WORLD INHABITED LIKE OUR OWN.

DESCRIPTION OF THE PLANET MARS.—DISCOVERY OF ITS SATELLITES.

WHEN, sixteen years ago, I published the last edition of my work—"The Plurality of Inhabited Worlds"—I did not expect to see the speedy confirmation that the progress of astronomy was to give to my essay, by allowing us, so to speak, to put our finger on the manifestations of planetary life. On one hand, those samples of other worlds—the aerolites—have brought us, in their composition, certain elements which play a very extensive *role* in life—such as oxygen, hydrogen, chloride of sodium, and carbon. The aerolite which fell at Orgueil (Tarn-et-Garonne) in 1864, brought us coaly matter—carburets that are due, like peat, to vegetable remains; the one which fell at Lancé (Loir-et-Cher), in 1872, brought us salt. They had already brought us water in the form of hydrated oxide of iron. The worlds whence these fragments come, do not differ, then, essentially from our own. On another hand, by means of spectrum analysis, there has been discovered in the atmospheres of the planets, watery vapor identical with that which produces our fogs, our clouds, and our rains. But of all the studies made during these later years, the telescopic examination of the planet Mars offers us the most immediate confirmation of the existence of life beyond our globe. This neighboring world, indeed, presents analogies of the greatest similarity with our own. By its situation, we are permitted to observe its surface under the best of conditions for study, and the telescope detects configurations which denote the closest relationship of this globe with the one we inhabit.

It was through the continued and persevering study of the movements of Mars that Kepler discovered the laws



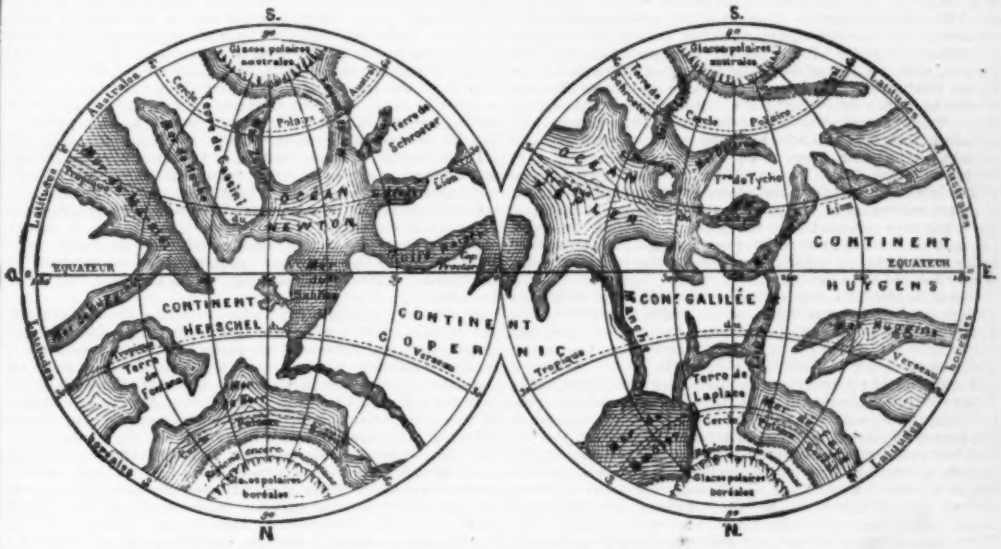
THE PLANET MARS.

which govern the system of the universe. To me, it seems certain that it is through a study of this same planet that the theory will be confirmed which will prove the philosophic crowning of astronomy—that of the plurality of worlds. By this double service Mars will have merited the esteem of thinking humanity, and will, perhaps, be able to have those follies and cruelties pardoned with which the god of war has so long inspired the poor unreasonable *genus homo* which people our earth.

Led by a persistent desire to find in practical astronomy itself a direct demonstration of this great truth of the plurality of worlds, I have specially occupied myself with observations of the planet Mars. I have studied it very particularly at those periods when it passed in close proximity with the earth, in 1869, 1871, 1873, 1875, and 1877. On comparing one with another, of the observations made by different astronomers, I have succeeded in collecting together, in this respect, numerous and decisive documents. The results of these observations and discussions are satisfactory for the solution of the curious problem as to the state of life on the surface of the planets. I propose to bring them together here in a special study of the world of Mars, and I hope that they will interest all those whose thoughts sometimes love to quit the material interests of earth to soar toward the mysteries of the unknown—toward those silent worlds suspended, like our own, in space, and which seem like so many interrogation points placed in the heavens to excite our curiosity and sympathy.

Our readers are aware that the planet Mars comes next after our own in the order of distance from the sun. Our orbit is traced at 95,000,000 of miles from the sun, and that of Mars at 145,000,000. When the two planets are both on the same side of the sun, the difference that separates them is then only 50,000,000 miles; and this may even decrease to 35,000,000, because neither Mars nor the earth moves in a circular orbit, so that their distances from the sun increase or diminish according to epochs.

In order that the observation of Mars may give good results, two conditions are requisite, besides that of its relative proximity at the time of its opposition: the atmosphere of the earth must be pure at the place of observation, and the



GEOGRAPHY OF MARS ACCORDING TO THE MOST RECENT OBSERVATIONS.

atmosphere of Mars must not be cloudy. In other words, it must be while the inhabitants of the latter planet are enjoying fine weather. In fact, Mars is surrounded, like our globe, with an aerial atmosphere which, from time to time, becomes covered with clouds just as our own does. Now, these clouds, in stretching out above the continents and seas, form a white veil which hides them from us totally or partially. The study of the surface of Mars in this case is difficult or even impossible. It would be as useless to attempt to distinguish this surface when it is cloudy weather on Mars, as it would be to try to distinguish the villages, rivers, roads, and railroads of our country from a balloon while sailing above an opaque stratum of clouds. From this it will be seen that the observation of this planet is not so easy as one might at first sight suppose. Moreover, the purest and most transparent terrestrial atmosphere is usually traversed by cold or warm currents of air, flowing in different directions above our heads; so that often, during the calmest night, it is almost impossible to succeed in making a passable drawing of a planet like Mars, the image seen in the reflector being wavy, tremulous, and confused. In spite of these troublesome conditions the planet Mars is the best known of all.

The moon alone, on account of her proximity, the constant transparency of her rare atmosphere, and the absence of clouds, has been the object of a more assiduous and more particular study, so that her geography is to-day completely determined. But after the moon, Mars is the best known of all the stars. No planet can be compared with it in this respect. Jupiter, the largest, and Saturn, the most curious (both more important than Mars and more easy of observation in their entirety, on account of their dimensions), are enveloped in an atmosphere constantly loaded with clouds, so that we never see their surface. Uranus and Neptune are only brilliant points. Mercury is almost always eclipsed, like courtiers, in the radiance of the sun. Venus, Venus alone, might be compared to Mars: she is as large as the earth, and consequently twice the diameter of Mars. She is nearer us, and may even come within 25,000,000 miles of us. But she has one fault—that of gravitating between us and the sun, so that, at her nearest proximity, her lighter hemisphere being naturally always on the side toward the sun, we see only her dark hemisphere bordered with a narrow crescent (or, more correctly speaking, we do not see her). The result is that her surface is more difficult of observation than that of Mars. So she is in this respect excelled by the latter, which, of all the sun's family, is the individual whose acquaintance we shall form most quickly.

We have already been able to study and map the geography of Mars. The most striking thing on a first examination of the general appearance of this planet, is that its poles are, like those of the earth, marked by two white zones—two caps of snow. Both the north and south poles are at times so brilliant even that they seem to extend beyond the edge of the planet, in consequence of that well known effect of irradiation which makes a white circle appear larger to us than a black one of the same size. The ice varies in extent; it becomes heaped up and extends around the poles during winter, while it melts and retreats during summer. Its entire mass occupies a greater superficial area than our polar ice does, and sometimes extends down as far as 45° of latitude, that is, to regions which would correspond to the situation of France on the earth. This polar snow is seen to form a well marked circle on the figure which accompanies this article, and which is reproduced from one of my telescopic drawings made on the 29th of June, 1873. On this day the planet was exhibiting a beginning of phase.

At first sight the planet seems to bear some analogy to our own, as regards the division of its climates into frigid, temperate, and torrid zones. An examination of its topography shows us, on the contrary, quite a characteristic dissimilarity between the configuration of this globe and that of our own.

In fact, upon the earth there are more seas than lands; three-fourths of our globe are covered with water. It is not the same with the surface of Mars, notwithstanding that attempts have often been made to apply such comparisons to its continental and oceanic divisions. Water does not cover three-fourths of this planet; for there is almost as much land as sea, and the seas are mediterranean. Moreover, several narrow seas, true channels, afford communication between the different latitudes. The continents of Mars are of a yellowish-red shade of color, and its seas present themselves to our eyes under the appearance of grayish-green blotches, their color still more heightened by the effect of contrast with the reddish color of the continents. It is this prevailing color of the land which gives the planet that ruddy light by which it is at all times distinguished from the other planets and from the fixed stars.

The color of the water on Mars appears, then, to be the same as that of terrestrial water. As for the land, why is it red? It was at first supposed that this tint might possibly be due to the atmosphere of the "warrior planet." It in no wise follows that because the air of our own world is blue, that of other planets should be of the same color. It might be possible to suppose, then, that the atmosphere of Mars was red; and the poets of the planet would, therefore, extol this glowing shade. Instead of diamonds sparkling in an azure vault, the stars there would be golden fires blazing in scarlet; the white clouds would be suspended in a red heaven, and the splendors of the setting of centupled suns would produce effects no less remarkable than those that we admire upon our sublunary globe. But there is nothing of this. The color of Mars is not due to its atmosphere; for, although this veil extends over the whole planet, neither its seas nor its polar snows come under the influence of this coloration; and Arago, by proving that the limb of the planet is less colored than the center of the disk, has shown that this coloration is not due to the atmosphere, for if it were, the rays reflected from the edges of the planet in order to reach us, having more air to pass through than those that come to us from the center, would be, on the contrary, more deeply colored than the latter.

Can it be that this characteristic color of Mars, so visible to the naked eye, and which is undoubtedly the cause of the warlike personification with which the ancients invested the planet, is due to the color of the grass and other vegetation which must cover its plains? Can there be red meadows and red forests up there? Can it be that trees with ruddy foliage offer a substitute there for our quiet and delightfully shaded woods; and are our scarlet poppies typical of the botany of Mars? It may be remarked, in fact, that an observer situated on the moon, or even on Venus, would see our continents strangely tinged with a greenish shade. But in autumn he would see this shade disappear in those latitudes where the trees lose their foliage, and afterward would see snow covering the country for entire months. On Mars, the red color is constant, and we remark it in all latitudes, during their winter as well as their summer. It varies only according to the transparency of its atmosphere and of our own. That is no obstacle, however, to the fact of the vegetation of Mars being the principal cause of this general tint. The ground cannot be everywhere bare like the sands of Sahara. It is probably covered with vegetation of some kind or other; and, as it is not the depths of the soil, but its surface, that we see, it must be that the surface-covering—the vegetation, whatever it is—has red for its predominant color, since all the land of Mars offers this same curious aspect. We speak of the vegetation of Mars, we speak of its polar snows, we speak of its seas, of its atmosphere, and of its clouds, as if we had seen them. Are we authorized to create all these analogies? In reality, we see only red, green, and white *blotches* on the little disk of this planet. Is the red indeed *terra firma*, is the green really water, and is the white indeed snow? In a word, is this truly a world like our own?

Yes! Now we are able to assert it. The appearance of Mars varies constantly. White spots move about over its disk, too often modifying its apparent configuration. These spots can be nothing but *clouds*. The white spots at its poles increase or diminish according to the seasons, exactly like our terrestrial circumpolar ice-fields which would offer precisely the same aspect, the same variations, to an observer placed on Venus. Then these white polar spots of Mars are like our frozen water. Each hemisphere of Mars is more difficult of observation during its winter than during its summer, being often covered with clouds over its greater portion. This is also precisely what would happen to an observer from Venus, with respect to our earth; every one knows that the sky is oftener overcast in winter than in summer, and there are entire weeks during which fogs or clouds prevent us from seeing the heavens.

GALILEO AND THE INQUISITION.

To the Editor of the Scientific American:

The substance of a letter from Mr. H. D. Garrison to the *Pharmaceutist and Chemist*, of Chicago, published in your issue for February 15, contains so much that is at utter variance with truth, that I venture to send you corrections. Mr. Garrison's story to the *Pharmaceutist* is so well put together, and so plausibly told, as to deceive any one not conversant with the matters of which he treats; therefore, in the interest of truth—in justice to those great scientific lights who have lived and labored both before and since Galileo's time, and who are wronged by the assertion that Galileo had fully confirmed the Copernican theory—in justice to the feelings of the very large proportion of the readers of your excellent periodical which have been aspersed by the ignorant or malicious assertions of Mr. Garrison, I trust to your sense of honor and fair dealing for the publication of this brief defense:

Galileo was certainly a great mathematician and philosopher, and made many scientific discoveries, such as the doctrine of motion, the theory of falling bodies, the cycloid (very probably), the gravity of the air, the invention, or rather re-invention, of the pendulum; the propagation, properties, and ratios of sound, etc., together with his astronomical discoveries, by means of his then enlarged though now comparatively very diminutive telescope, showing the phases of Venus and the movements of the satellites of Jupiter; but to say that he "fully confirmed" the Copernican theory is simply ridiculous. It was not until centuries afterwards, when the discoveries of Kepler, Torricelli, Newton, Roemer, Bradley, and a host of others, had cast further light on the question that that theory had begun to be regarded as a fact by scientific men. It is now generally conceded that Galileo made many serious mistakes, such as the theory of the tides, on which he rested so much, and which brought discredit on his real discoveries. Even Bacon scornfully rejected his theories; and we are told by the celebrated Delambre, that until the velocity of light was ascertained by Roemer, the aberration of light calculated by Bradley, and the laws of gravitation (now beginning to be questioned it would seem) were established by Newton, all the Copernicans were reduced to mere probabilities.

The fact of Mr. Garrison's writing his letter from Florence, for some years the residence and the scene of Galileo's labors, would naturally lead people to suppose him correctly informed. I propose to show that he was not. The drift of his letter is unmistakably sensational—to make Galileo a martyr of science, and to hold up the church to execration as his narrow-minded persecutor, an enemy to scientific research, and to the Copernican system in particular. His statements are briefly as follows: That Galileo was arrested and condemned for maintaining the Copernican theory, which, he says, "was then regarded as heretical in the highest extreme;" that the only alternative left him was the renunciation of that theory or "indefinite imprisonment, probably ending in death;" that the doctrine of Copernicus was "completely confirmed" by Galileo (which I have shown was not the case), but that "the church," unwilling to accept it, "then unused to reverses, and unskilled in explaining away scientific contradictions, saw no way to meet the issue successfully, but by physical force;" that Galileo had before his eyes the fate of Hypatia, and Giovanni Bruno, who, a short time before, being driven successively from England, Germany, and Switzerland, imprisoned in Venice for six years, was finally sent to Rome and burned at the stake—"and all this," says Mr. Garrison, "for having simply *argued* [the italics are his own] in favor of the probability of the Copernican doctrine;" that Galileo, although having submitted to the Inquisition, was detained a prisoner for life in his own house at Arcetri, not being permitted to leave it "even to attend church, or to secure medical advice at Florence; nor was he even permitted to see his friends until after he became blind;" that, finally, "at his death he was refused burial in consecrated ground, and his right to make a will contested." We will see how far these assertions can stand the test of truth; and first, naturally, as to the Copernican theory being "then regarded as heretical in the highest extreme." This brings us back a little, but I will be brief.

A century and a half before Galileo's time the Copernican theory was written upon and publicly taught by eminent churchmen, and for more than three quarters of a century it had been publicly written upon and discussed by some of the most learned men in Europe. A century and a half before the celebrated scientist and scholar, Cardinal Nicholas of Cusa, taught and wrote upon it, and was never reproached therefor. The son of a poor fisherman on the banks of the Moselle, Nicholas had, through the liberality of eminent ecclesiastics, obtained a liberal education in the most famous universities of Germany and Italy, eventually became canon of Liege, and in that capacity assisted at the Council of Basle in 1431. Previous to this he had written several works, among them a treatise on astronomy, in which he boldly laid down his conviction that the earth, and not the sun, was in motion, and that the true system of astronomy should be called heliocentric and not geocentric. This opinion he maintained side by side with his friend, Cardinal Ceserni, before the assembled Fathers of the Council. Not that astronomy had necessarily anything to do with church matters, but because learned ecclesiastics naturally took an interest in it as well as in the other sciences. "Was he summoned to Rome to answer for his bold speculations?" asks the Very Rev. Canon Murphy, of Dublin, in a lecture on "Galileo." "Yes," he continued, "he was summoned before the reigning Pontiff, Nicholas V., but it was to receive the highest dignity the Pope could confer upon him—the Cardinal's hat, and with it the Bishopric of Brixen, in Tyrol." This does not look as if it had been regarded as a heresy.

Again, Celius Calcagnini, born in 1479, also published a work in which he endeavored to prove "*quod cœlum stet, terra autem moveatur*," but there is no record of his being regarded as a heretic or persecuted for it.

Still later, in 1533, ten years before the publication of Copernicus' work, "De Revolutionibus Orbium Cœlestium," (Marienburg, 1543), John Albert Widmanstadt, while on a visit to Rome from Germany, was invited by Pope Clement VII. to give in his presence, at the Vatican, an explanation of the Copernican system. He did so, lecturing on the subject in the Vatican garden; and the Pope, in token of his appreciation and favor, presented him with a valuable Greek manuscript, which is now preserved at the Royal Library of Munich, with the event noted on a fly-leaf in Widmanstadt's own handwriting.

In 1510, Leonardo da Vinci had connected his theory of bodies with the earth's motion, "showing," as Whewell says (quoted in the *Catholic World* for Jan., 1879), "that the heliocentric doctrines were fermenting in the minds of intelligent men, and gradually assuming clearness and strength. But no word of persecution here.

We now come to Copernicus, the humble, holy, and learned Catholic priest, from whom the system takes its name. He was Canon of Frauenburg, in Prussia, and nephew to the Bishop of Ermeland, Lucas Walzelrodt, or as he is sometimes called, Waisselrodt Von Alten (in whose absences Copernicus took charge of the diocese). Having passed the regular course and received his degree of doctor of medicine at the University of Cracow, Copernicus afterwards, when a priest, made three divisions of his time—one for the duties of the priesthood, one for the gratuitous practice of medicine among his friends and the poor, and one for the pursuit of astronomical and other scientific studies. He spent twenty-three years in completing his astronomical system, but had not yet published it when it became known to his friend, Cardinal Schomberg, who urged its publication and offered to pay the expenses. The Bishop of Culm, Tindemann Giese, had also for a long time advocated its publication, but the modesty of the learned canon and his desire of further improving this work withstood their importunities. Finally, when it was published, it was at the expense of Cardinal Schomberg, who generously gave the money in advance. Copernicus had some years before been a professor in Rome, where he was held in high estimation, and was frequently, after leaving it, consulted on mathematical questions, notably in 1516, concerning the improvement of the calendar. He dedicated his work, by permission, to Pope Paul III., and placed it under his protecting ægis, in order "that the authority of the pontiff might silence the calumnies of those who attacked these opinions by arguments drawn from the Scriptures." Copernicus died a few hours after receiving the first printed copy of his book, and was buried at the foot of the altar where he usually said Mass. Thirty-eight years afterward, Cromerus, Bishop of Ermeland, had a suitable inscription placed on his tombstone, which may be seen to this day. A monument was erected to his memory in the Catholic city of Cracow in 1822, by the Polish Catholics, than whom none are more devoted to the church, and a colossal statue was also erected by Thorwaldsen, in Warsaw, the capital of the same Catholic Poland. From these circumstances we may estimate the value of the gratuitous hints thrown out by chroniclers and writers that Copernicus' death so soon after the publication of his book probably saved him from persecutions similar to those of Galileo. No word of "heresy" or "persecution" here, notwithstanding the length of time that had elapsed, the prominence given to the astronomer's name, and the men of various stations in life, clerical and lay, that had done him honor, and this in a thoroughly Catholic country.

From the foregoing may plainly be seen the groundlessness of Mr. Garrison's assertion of the Copernican theory being regarded as "heretical in the highest extreme," and we are forced to seek other reasons for Galileo's condemnation. If there be any doubt about its not being regarded as heretical, perhaps Galileo's own assertion may dissipate it. In a letter to Piccheria (quoted in the *Catholic World's* article), Galileo writes, after the decree of 1615: "The result has not been favorable to my enemies, the doctrine of Copernicus not having been declared *heretical*, but only as not consonant with Sacred Scripture; whence, the whole prohibition is of those works in which that consonance was maintained." It was at this time his enemies first circulated the false reports that he had been tried, condemned, and punished—reports which stung Galileo so much that he went to Cardinal Bellarmine and obtained a writing over his (the Cardinal's) signature, contradicting them. The Cardinal's certificate bears date of the 26th of May, 1616.

So that we see it was Galileo's obstinacy in making a theological or scriptural question of the Copernican theory, and at a time when there were no substantial proofs in its favor of being more than a theory, that first brought him into trouble. Cardinal Barberini, afterwards Pope Urban VIII., had advised him "not to travel out of the limits of physics and mathematics, but confine himself to such reasonings as Ptolemy and Copernicus used; because, declaring the views of Scripture the theologians maintain to be their particular province." Therefore, we see the fallacy of the claim put forth that Galileo was a martyr to science in general, and the Copernican theory in particular; in fact, he, by his rashness, undid much of what Copernicus had done. Even Chambers, or rather the learned Protestant who wrote the article on "Galileo" for his Encyclopedia, candidly acknowledges that "no great man had ever less claim to the title" of martyr; that "the great deficiencies in his (Galileo's) character were *a want of tact to keep out of difficulties*, and a want of moral courage to defend himself when involved in them. His biting, satirical turn," continues the encyclopedist, "more than his physical discoveries, was the cause of his misfortunes." Long before Galileo went to Rome, and while yet teaching in Pisa, his native city, the overbearing and dictatorial spirit of the man had raised such a storm of ill-feeling against him, and entangled him in so many broils that he was glad to leave Pisa and take a professorship in Padua. In the social circle, it is true, Galileo was genial and affable, but, like many others, even in our own day, in business matters he was arrogant, overbearing, and so self-confident that he would neither take advice nor brook restraint. Hence it was that when he took a notion to prop up his opinions with Holy Scripture, a check was put to his actions, and not unjustly, for although it happens that later scientific discoveries have borne him out in supporting the Copernican theory, they have also condemned the many errors with which he had hampered it, and more particularly the very one of all others upon which he rested the truth of that theory, namely, the ebb and flow of the tides, which has since been proved fallacious. It is asserted by many that on discovering the sun-spots he ascertained also the movement of that luminary, which was not the case; he supposed it stationary, or revolving only upon its axis, which was another serious mistake. The Pope had often told him, in private conversation, that his theory of the tides was untrue, and that he weakened his position by resting mainly, if not altogether, on such a false basis—all which scientific research has since proved true. Hence we see that even from a scientific point of view, Galileo was more wrong than right, for he had not been able to see and turn to account the full extent of the discoveries he had made with his telescope. It was not till long afterwards that they brought fruit, and then only by accident. It was not till 1672 that Richer, when sent to Cayenne by the French Academy of Sciences, found it necessary to shorten the pendulum on account of the centrifugal force of the earth in its rotation on its axis, as afterwards explained by Newton and Huygens; in the same year Roemer, the Danish astronomer, discovered the transmission of light and the value of its velocity—verified in 1676; and it was not until fifty years later that Bradley's discovery of the aberration of light was made. Thus, we see, more than a century had elapsed after Galileo's death before any positive proofs had been obtained, although Mr. Garrison tells us he had "fully confirmed" the Copernican doctrine. When we see Galileo asserting the immobility of the sun, failing in his method of ascertaining the longitude at sea when he thought he had succeeded, resting the truth of the Copernican system on his "Theory of the Tides" (published in 1618), and then attempting to force the Scriptures to prove his assertions, we need not wonder that the tribunal of the Inquisition bade him desist, as being on dangerous ground. "The dignitaries of the Church," says Chambers' Encyclopedia, "who persecuted Galileo warned him beforehand, in the friendliest way, to be 'more prudent'"—to confine himself to science and mathematics, and let the Scriptures alone. Moreover, the same authority continues, a fact which it would be well that Mr. Garrison would bear in mind: "It is also right to add that the Congregation of the Inquisition, by which Galileo was condemned, is not believed by Roman Catholics to speak with the plenary authority of the Catholic Church, nor are its decisions regarded as infallible even by the most extreme Ultramontane."

Finally, as to the assertions that Galileo was not permitted to leave his house even to attend church or obtain medical advice, or to see his friends until he became blind—that at his death his right to make a will was disputed, and he was refused burial in consecrated ground, we can say on the best authority, both Catholic and non-Catholic, that they are sheer fabrications, with no foundation in fact. It is true that Galileo was condemned by the Inquisition (and not by the Vatican Council as Mr. Garrison calls it), (1) for a contempt of its authority, (2) for a breach of trust in using the name of a government functionary, Riccardi, for an illegal purpose in the publication of a work "containing a high estimate of his own discoveries," says Delambre, "but depreciation of others," in which the confidence of his personal friends, including even the Pope, was outraged, and which really contained so little except personalities that Arago says he would "advise scholars not to lose their time in reading it,"—for these things he was condemned by the Inqui-

sition to imprisonment at its pleasure, and to recite once a week for three years the seven penitential psalms—reserving to itself the privilege of moderating, commuting, or taking away in whole or in part the penalties and penances. But it is also a fact that the same Pope Urban VIII., who before had settled upon Galileo a pension for life of 100 crowns a year, and on his son Vincenzo a similar pension of 60 crowns, *immediately commuted the sentence* pronounced on the 22d of June by the Inquisition, and that on the 6th of July following Galileo left Rome for Sienna, where he remained with one of his most intimate friends, Archbishop Piccolomini, until his return home, in December, to his villa at Arcetri. "Here he spent," says the celebrated Protestant Encyclopædist Rees,* "the residue of his days, prosecuting his studies and observations, *and communicating the result of them occasionally to the public;* AND HERE HE WAS VISITED BY PERSONS OF THE PRINCIPAL RANK AND CHARACTER AT FLORENCE."

Arcetri was only about a mile from Florence, and not far from it was the Convent of St. Matthew, where Gilileo's two daughters were cloistered nuns, and where he often went to see them, to enjoy their conversation and their many proofs of tender filial affection. "Thus the last years of the philosopher were spent," says the Very Rev. Canon Murphy, "not, as has often been asserted, moping about the gloomy precincts of a prison, but among the amenities of a charming villa," and in converse and communication with his friends. "He was comforted and strengthened in the hour of death by the last sacraments and by the proper blessings, and his eyelids were closed by the hands of his affectionate son and of his cherished friends, Torricelli and Viviani."

As to the assertion that Galileo "was refused burial in consecrated ground," it is or should be well known that his body rests in the Cathedral of Santa Croce, at Florence, "along with some of the remains of the most eminent men of modern Italy." B. S. C.

Notre Dame, Indiana, March 13, 1879.

THE TAILS OF COMETS.

PROF. BREDIKHINE, of St. Petersburg, writes Mr. Proctor in the Newcastle *Weekly Chronicle*, has made some interesting researches into the evidence respecting the tails of comets. He shows reason for believing that these appendages may be divided into three distinct classes, according to the different relations between the attractive and dispersive power of the sun. The latter power he considers to be, in all probability, modified by the different properties of the particles of which the tail is formed. There are few subjects of inquiry more difficult and perplexing than the phenomena of comets' tails. The evidence seems unmistakably to point in some cases to a true repulsive action excited by the sun, and yet nothing seems harder to understand than the possibility that the sun should exert such a power in so energetic a manner as to produce the amazingly rapid extension of tail matter seen in certain cases. Thus the tail of Newton's comet seen after the comet had made its nearest approach to the sun, must have been thrown out in less than a day (probably in less than a few hours) to a distance of more than ninety million miles. Under the sun's gravitating power, tremendous though that power appears, the comet, with all the velocity it had already acquired, took more than four weeks in traversing the same distance. Tyndall's ingenious attempt to explain the formation of comets' tails as due to the actinic energy of rays which have passed through the comet's head, fails to account for the phenomena presented by many long-tailed comets. Professor Tait's sea-bird analogy, by which the formation of a comet's tail is compared with the coming into view of a flight of sea-birds, as the plane of their array comes to coincide with the observer's eye, would never have been advanced by anyone familiar with the history of the most important comets, or even with the history of any one of the great comets which have been visible for more than a few days. What Sir John Herschel wrote more than forty years ago has never yet been invalidated, viz., that the phenomena of comets can only be explained by assuming the existence of an intense repulsive force, excited by the sun on the thin material raised by his heat from the surface of comets approaching him from interstellar space.

CONSTITUTION OF NEBULÆ.

IN the "Investigations upon the Height of the Atmosphere and the Constitution of Gasiform Cosmical Bodies," A. Ritter deduces the following law: "If, in consequence of increase or diminution of heat, the radius of the gaseous globe undergoes a change, the temperature of its center also changes; but the product of the radius into the central temperature is constant." If p, v, T, respectively, designate the pressure, specific volume, and absolute temperature of a definite, minute portion of the body, $pv^{\frac{4}{3}}$ = constant; $Tv^{\frac{1}{3}}$ = constant; $\frac{T^4}{p}$ = constant. Since Neptune's orbital radius is about 6,000 times as great as the sun's present radius, according to the above law the sun's central temperature is now about 6,000 times as great as when, according to the Kant-Laplace hypothesis, the sun was expanded to the orbit of Neptune. Of the whole work which has been performed by gravity during that immense interval, more than four-fifths is still stored within the sun's mass in the form of heat.—*Ann. der Phys. u. Chem.*

TREATMENT OF FISTULA IN ANO.—A NEW METHOD.

By I. J. SUGGS, M.D., of Texas.

SOME years since I was called in consultation in case of fistula in ano. After examining the case, I conceived the idea of introducing a tube into the rectum so as to prevent the action of the sphincter, and thereby allow the fistula to heal. It was agreed to. I had a silver tube made as follows: 3 inches long, about 1¼ inches in diameter at the point, larger at the base, flared some small holes in the base so as to confine it with a bandage. Made an obturator similar to that of a speculum uteri. After having the bowels well evacuated the tube was introduced and confined with a T bandage, the obturator removed and a plug of cotton introduced, the fistula well cleansed and a diluted tincture of iodine injected. Five days after the operation the tube was removed and the fistula perfectly cured.

I have not had a case of fistula since in which to try again the above treatment.—*Southern Medical Record.*

RINGWORM.

DR. JNO. V. SHOEMAKER, in a paper read before the American Medical Association on "Ringworm in Public Institutions," states that, while treating a large number of cases of ringworm, which occurred in one of the public institutions for children in Philadelphia, he scraped some of the scales from the scalp of one of the children, and also from the chest of another, and applied them to the bodies of two cats. For three days no change was perceptible on the parts upon which the scales were placed; on the fourth a small meal like patch was detected upon one, and on the other the hairs began to fall out. The fifth day the patches assumed the characteristic circular form, and the affection continued to spread rapidly until spots the size of a large coin were almost denuded of hair. Scales from the patches of one of the cats were reinoculated on a healthy portion of the scalp of one of the children and thigh of another, with the effect of producing the circumscribed spots of ringworm. Two specimens were now prepared, one from the inoculated child, the other from one of the cats, and revealed under the microscope fungi of a luxuriant growth, threads being present in large quantities.

Ringworm owes its origin to a vegetable parasite, the *Trichophyton tonsurans*. It generally commences among those that are improperly cared for, and, as it is exceedingly contagious, it spreads rapidly to those coming in contact with the infected. The fungus has a predeliction for the strumous and debilitated, and flourishes upon them luxuriantly.

Among the fifty cases afflicted on the occasion referred to the author found that a large percentage were the children of subjects of chronic disease, worthless and confirmed drunkards, and inmates of charitable institutions or almshouses. The affection frequently has its origin in the lower animals, and is transmitted from them to children and adults. A number of cases are on record in which it has been communicated directly from cows, calves, oxen, horses, and cats to individuals, and then to other members of the same family. A well-marked example of its direct transmission from a cow to an individual came under the author's notice and treatment a short time since. The experiments on cats, noted above, are also additional strong proof that the fungus can be transmitted from lower animals to children, and from individuals to animals, and also verify the fact that the scales of the scalp are capable of producing by inoculation ringworm on other parts of the body.

Dr. Shoemaker states that his observation has been that, when the affection attacks the body and is not complicated, it is easily cured; but when it involves the head it is a most tedious and unmanageable disease, owing to the mischievous influence of the hair. He believes, however, that the failure to promptly eradicate the disease in the majority of cases in public institutions is due to negligence, want of patience, and the inability on the part of nurses and attendants to properly understand the orders of the physician.

ELEPHANTIASIS AND FILARIA.

A RECENT number of the *Lancet* contains a lecture, by Sir Joseph Taylor, on *Elephantiasis arabum*, or "elephant leg," in which the author gives the most recent views as to the cause and proper treatment of the disease. This malady is one seldom met with outside the limits of tropical and inter-tropical countries, and occurs in the latter generally near the coast, where the malaria and sea air mingle. Nothwithstanding its common name, which is derived from the supposed resemblance of the parts affected to the limb of an elephant, the disease is not confined to the leg, but may attack other parts of the body. It is totally distinct from leprosy (*Elephantiasis Græcorum*), with which, owing to its name, it is sometimes confounded. They are unlike in symptoms, as in nature, and have nothing in common, although they may coexist. Dr. Taylor thinks it would be well to abandon elephantiasis as a generic name for leprosy. The ordinary form in which the disease occurs is hypertrophy of the integument and subjacent areolar tissue of some part of the body, especially of the legs and external genital organs, and the affected parts often obtain an enormous size. The skin is formed into hard, rough masses or folds, in appearance not unlike the skin of an elephant's leg. The feet and toes are sometimes almost hidden under it, and scrotum and labia form enormous outgrowths, often of great weight, accompanied by large tumors, with white, milk, or chyle-like contents. From the male patient such tumors have been removed weighing upward of 100 pounds. The disease affects both sexes and all ages. No race is altogether exempt, but the dark-skinned seem more liable to suffer than the fair. Men suffer in larger proportion than women. The period of life between twenty and forty is that most prone to be affected. Waring states that the lower animals are not exempt; even birds have been known to suffer from a swelling of one or both legs, which, though unaccompanied by fever, was in all respects similar to the hypertrophy of elephantiasis. It appears that the disease does not, of necessity, shorten life, though no doubt dangerous ulceration and even gangrene may occasionally supervene.

The malady is found in India, the Malayan Peninsula, China, Arabia, Egypt, the West Indies, South America, in some parts of Spain, and, probably sporadically, all over the globe, excepting, perhaps, the extreme northern and southern regions.

Various causes have been assigned for the disease in the regions where it prevails. Air, water, food, and, as it is frequent near the sea coast, eating fish, have been credited with it. The presence or vicinity of certain forms of vegetation, geological formations of soil, have each or all been regarded as causes. Certain climatic conditions—humidity, heat, malarious influences, combined with poor living—seem to be concerned as predisposing causes; and it has frequently been observed that removal from the locality checks, while return to it reproduces the disease; and now, according to Lewis, Manson, Bancroft, and others, the presence of *filaria* in the blood and lymph is considered to be largely concerned in the causation—at all events, this parasite is frequently associated with, if not the cause of, the disease. It cannot be denied that the causal relation of the nematode worm to elephantiasis and other morbid conditions has some show of probability, although more information must be obtained before a decided opinion can be formed. The discovery by Dr. Manson that the mosquito, as an intermediary host, is instrumental in propagating the filaria, and consequently the disease is important and worthy of careful consideration in both an etiological and sanitary point of view. In connection with this it is interesting to learn that Dr. Manson, in China, considers that the geographical distribution of elephantiasis is much the same as that of the mosquito. Further investigation may confirm or it may reject these views, but we cannot but recognize the importance of the discoveries, though the precise import of their causal relations to elephantiasis or other diseases is still *sub judice*.

THE CHEMISTRY OF PLANTS.

By R. WARINGTON.

GERMINATION.

THE seed is a storehouse of concentrated plant food, intended to nourish the germ till the root and leaf are developed. In the seeds of the cereals, and of many other plants, the chief ingredient is starch. Another class of seeds, of which linseed and turnip-seed are examples, contain no starch, but in its place a large quantity of fat. A seed generally contains a considerable amount of albuminoids; its ash is rich in phosphoric acid and potash.

For germination to take place, moisture, oxygen, and a suitable temperature are necessary. Under these conditions the seed swells, oxygen is absorbed, a part of the carbonaceous ingredients is oxidized, heat is developed, and carbonic acid evolved. During these changes the solid ingredients of the seed gradually become soluble: the starch and fat are converted into sugar; the albuminoids are converted into amides—as asparagin, probably also into peptones. With this supply of soluble food the radicle and plumule are nourished; they rapidly increase in size, emerge through the coats of the seed, and, if the external conditions are suitable, soon commence their separate functions as root and leaf. The process of germination may be easily studied in the ordinary operation of malting barley.

Seeds buried too deeply in the soil may not germinate for lack of ogygen. If germination takes place the plumule may fail to reach the surface, the store of food in the seed being exhausted before the layer of soil is penetrated, and daylight reached.

THE SOURCES OF PLANT FOOD.

The Atmosphere.—We have already stated that the whole of the carbon of plants is obtained from the carbonic acid present in the atmosphere; 10,000 volumes of air contain about 3½ volumes of carbonic acid, or about 1 lb. of carbon in 3,500 cubic yards of air.

The atmosphere also contains a very small and variable quantity of ammonia. Schlœsing found from 1 lb. in 6,000,000 cubic yards, to 1 lb. in 119,000,000 cubic yards. The quantity is greatest, according to the same experimenter, in warm southerly winds. The ammonia of the air is perhaps directly absorbed by plants to a small extent, but is rendered available chiefly through absorption by the soil, and by means of rain, which brings it in solution to the earth.

The atmosphere also furnishes a small amount of nitric acid. The nitrogen and oxygen of the atmosphere combine under the influence of electric discharges, nitrous acid being formed; this is converted into nitric acid by the action of ozone, or peroxide of hydrogen. This formation of nitric acid in the atmosphere is the only original source of combined nitrogen on our globe the existence of which has been placed beyond dispute.

The total amount of nitrogen, in the form of ammonia and nitric acid, annually carried to the soil by rain, varies in different years and places. The average of many experiments in Germany gives 9·45 lb. of nitrogen per acre. The average of two years experiments at Rothamsted gave 7·47 lb.

Rain also furnishes small quantities of alkaline chlorides, especially in the neighborhood of the sea. At Cirencester the chlorides are equal to about 30 lb. of common salt per acre per annum; further inland the quantity is smaller.

The Soil.—All soils have been produced by the disintregration of rocks; the character of the soil largely depends on the character of the rock from which it has been formed. The principal ingredients of soils are sand, clay, carbonate of calcium, and humus; as each of these preponderate the soil is said to be sandy, clayey, calcareous, or peaty.

Sand is either composed of pure quartz (silica), or consists of fragments of more complex minerals—mica, for example. When the former is the case, the sand will supply no plant food; but in the latter case the gradual decomposition of the mineral will slowly increase the ash constituents available for the plant.

Clay is a silicate of aluminum, and if absolutely pure would furnish nothing to the plant; it always, however, contains some potash. Clay has the important property of absorbing and retaining phosphoric acid, ammonia, potash, lime, and other substances necessary for plant nutrition.

The calcareous matter of soils supplies lime to the plant; limestone will also generally contain phosphoric acid. Carbonate of calcium is beneficial to the soil in many ways. It preserves the particles of clay in a separate coagulated condition, thus making heavy soils friable and pervious to water. It enables clay to exercise its absorbent power on various salts, which would otherwise escape its action. It also promotes the decomposition of vegetable matter, and the nitrification of the nitrogen which it contains.

The humus, or decayed vegetable matter of soils, has its origin in the dead roots, leaves, etc., of a previous vegetation. It is the only nitrogenous ingredient of soils. A black soil, rich in humus, is sure to be also rich in nitrogen; a soil destitute of humus will contain scarce any nitrogen. The relation of these ingredients of soil to water and heat must be briefly noticed.

Of all soil ingredients sand has the least, and humus the greatest capacity for retaining water. Light sandy soils thus suffer most from drought, while applications of farmyard manure, and the ploughing in of green crops, increase the water-holding power of a soil.

Dark-colored soils absorb the greatest amount of heat from the sun's rays, and light-colored soils least. The presence of humus is thus favorable to soil warmth. Quartz sand is an excellent conductor of heat. A soil rich in sand will thus be warmed or cooled to a greater depth than a soil containing but little sand. Water has a powerful effect in cooling a soil, partly from its high specific heat, and partly from the immense consumption of heat during its evaporation. A wet soil is thus much colder than a dry one. The drainage of wet land thus results in a greater warmth of the surface soil, and consequently an earlier growth in spring.

The proportion of plant food present in soils is very

*"The Cyclopedia, or Universal Dictionary of Arts, Sciences, and Literature, by Abraham Rees, D.D., F.R.S., F.L.S., S. Amer. Soc. London; 1819." In 39 vols., accompanied by 5 vols. of steel engravings. A rare and valuable work, to which I have had access in the Library of the University of Notre Dame, Ind. It was published to subscribers at 60 guineas (about $300), secured to the heirs, and considered so complete and perfect that no second edition was to be or has been published. Nearly if not all the eminent men of the day were contributors to this publication, the list of their names filling nearly a page of the preface to the work. Among these it may suffice to mention Abernethy, Sir Humphry Davy, Mackay, Landseer, Flaxman, Bonnycastle, Pond, Lawrence, Donovan, Cavallo, etc.

small, even when the soil is extremely fertile. The surface soil (first 9 inches) of a pasture may contain 0·25 of nitrogen per cent., while soil of the same depth from a good arable field may yield 0·15 per cent., and a clay subsoil 0·05 per cent. A good surface soil may contain 0·20 per cent. of phosphoric acid, or not unfrequently a smaller quantity. Potash varies much, rising to 1·0 per cent., or none in some clay soils.

The weight of soil on an acre of land is, however, so enormous, that small proportions of plant food may be very considerable quantities. Nine inches depth of arable soil (clay or loam) will weigh, when perfectly dry, about 3,000,000 or 3,500,000 lb. A pasture soil will be lighter, the first 9 inches weighing, when dried and the roots removed, about 2,250,000 lb. Supposing, therefore, a dry soil to contain 0·10 per cent. of nitrogen, phosphoric acid, or potash, the quantity in 9 inches of soil will be about 3,000 lb. per acre.

A large part of the elements of plant food present in soils is in such a condition that plants are unable to make use of it. A soil may contain many thousand pounds of phosphoric acid or of nitrogen, and yet be in a poor condition, while a small dressing of readily available food, as superphosphate or nitrate of sodium, will greatly increase the fertility.

The nitrogen contained in humus is apparently not in a condition fit to serve as plant food; cereal crops at least are unable to appropriate it. By the action of an organized ferment present in the soil the humus is oxidized, and its nitrogen converted into nitric acid. Nitrification only takes place in moist soil, sufficiently porous to admit air, and at moderate temperatures. It is also necessary that some base should be present with which the nitric acid may combine; this condition is usually fulfilled by the presence of carbonate of calcium.

The fragments of rock present in soil, as stones, gravel, and sand, are as a rule of little value to a plant, the elements of plant food which they contain being in too insoluble a condition to be attacked by the roots These fragments of rock are slowly decomposed by the mechanical action of frost, and by the chemical action of water, and their contents are thus gradually made available to the plant. The solvent power of the water in a soil is greatly increased by the carbonic acid, and perhaps also by the humic acid it holds in solution. Water containing carbonate of calcium in solution is especially capable of attacking silicates.

If water is allowed to drain through a soil, it carries with it a part of the readily soluble matter which a soil contains. The substances chiefly removed by the water will be the nitrates, chlorides, and sulphates of calcium and sodium. When heavy rain falls these substances are washed into the sub-soil, and partly escape by the nearest outfall into the springs, brooks, and rivers. When dry weather sets in evaporation takes place at the surface of the soil, the water of the subsoil is brought again to the surface by capillary attraction, and the salts it contains are concentrated once more in the upper soil, forming in some rare instances a white crust of salt upon the surface.

Of these readily soluble salts the nitrates are of the greatest importance as plant food. The quantity of nitrates in a surface soil will vary greatly, depending on the richness of the soil in nitrogen, the extent of recent washing by rain, and on whether the soil is a bare fallow or under a crop. Where a crop is growing the nitrates will be kept nearer the surface, the evaporation of water from a growing crop being far greater than from a bare soil. The nitrates will also be constantly taken up by the roots, and employed as plant food. The loss of nitrates by drainage is thus far less when the land is under crop than in the case of a bare fallow.

Phosphoric acid, potash, and ammonia are very rarely found in drainage water. If a solution containing phosphoric acid, potash, or ammonia is poured on a sufficiently large quantity of fertile soil, the water which filters through will be found destitute of these substances. This retentive power of soil for phosphoric acid, potash, etc., is of the utmost importance in agriculture. The action is a complex one. All salts are doubtless retained to some extent by soil through mere mechanical adhesion; salts thus feebly retained, as nitrates and chlorides, can be removed by thorough washing with water. Other substances are, on the contrary, retained by chemical affinity; these are not removed by washing, or to but a small extent. The ingredients of the soil which exercise a chemical retentive power are the hydrates of ferric oxide and alumina, the hydrous silicates of aluminum, and humus.

Ferric oxide is a common ingredient of soils; to it the red color of many soils is owing. To the presence of ferric oxide the retention of phosphoric acid is chiefly due, an insoluble basic phosphate of iron being produced. Alumina acts in the same manner. Ferric oxide and alumina have also a retentive power for ammonia and potash, but the compounds formed are more or less decomposed by water. To the hydrous silicates the permanent retention of potash and other bases is probably chiefly due. Humus has a great absorbent power for ammonia. Other bases, as magnesia and lime, are retained by soil, but in a less powerful manner than are potash and ammonia.

Soils destitute of carbonate of calcium take up very little potash or ammonia when these are applied as salts of powerful acids, as, for instance, chlorides, nitrates, and sulphates. When carbonate of calcium is present the potassium or ammonium salt is decomposed, the base is retained by the soil, while the acid escapes into the drainage-water united with calcium. The presence of carbonate of calcium may thus greatly increase the retentive power of soil for bases.

There can be little doubt that the plant food contained in soil which is capable of being taken up by roots, exists either in solution (as, for instance, nitrates), or in the states of combination just referred to—that is, in union with ferric oxide, hydrous silicates, and humus. Different crops have very different powers of attacking these various forms of plant food.

The operations of tillage and drainage serve in several ways to increase the amount of plant food which is at the disposal of a crop.

By tillage the surface soil is kept in an open, porous condition. By this means the evaporation from the surface is lessened, capillary attraction being diminished, and the land consequently suffers less from drought; the water-holding power of the surface soil is also increased. A more important result of tillage is that the soil is thoroughly exposed to the influence of the air. Soils containing humus or clay will absorb ammonia from the atmosphere, and the soil is thus enriched with nitrogen. The organic remains of former crops and manuring are also oxidized by the atmosphere, the nitrogen being converted into nitric acid. The rocky fragments which a soil contains, as fragments of silicates or limestone, will be more or less disintegrated by the combined action of water and air, assisted by the products arising from the oxidation of vegetable matter, and a portion of the insoluble plant food is thus brought into a state suited for assimilation by the roots of crops.

By drainage the various chemical actions we have just mentioned are carried down to a greater or less extent into the subsoil, for as the water level is lowered the air enters from above to fill the cavities in the soil. By drainage also the depth to which roots will penetrate is increased, for roots will not grow in the absence of oxygen, and rot as soon as they reach a permanent water level.

Paring and burning is occasionally resorted to as a means of increasing the available plant food in a soil. It consists in burning the surface soil in heaps, which are then spread over the land. If the soil contains limestone it is easy to see that the phosphates of the limestone may become more available by the complete disintegration which attends the conversion into lime. If limestone and fragments of silicious rocks are present, the silicates will be attacked by the lime at a high temperature, and a part of the potash liberated from its insoluble combinations. To produce the best results it is essential that the burning should take place at a low temperature. This treatment of paring and burning is a very extreme one, and can be recommended only in few cases; it must be attended with an entire loss of the nitrogen in the soil burnt.—*Agricultural Gazette.*

MANUFACTURE OF PHOSPHORUS.*

By JAMES READMAN.

THE author remarked at the outset that his communication contained nothing absolutely new, but was simply an account of the practical aspects of the phosphorus manufacture. Various mineral phosphates are now used in the manufacture of phosphorus; bone ash is no longer remunerative, on account of its high price. Among the varieties of mineral phosphates are, Canadian phosphate, German or Nassau phosphate, Charleston phosphate, and Sombrero phosphate. The first stage in the manufacture of phosphorus is to decompose the calcium phosphate *completely* in a large cylinder with sulphuric acid of 110° to 115° Twaddell, with constant agitation. The calcium sulphate is then filtered off, and the filtrate is evaporated to about 80° or 90° T., and then allowed to cool. It contains over 25 per cent. of P_2O_5. It is then mixed with coarse wood charcoal, and dried in a muffle furnace. The proportion of charcoal to liquor is 1 to 5. This substance contains the phosphoric acid in a partially insoluble state, so that it is different in its properties from meta-phosphoric acid. The mixture is then transferred to retorts of Stourbridge clay, capable of holding 30 to 40 lbs. The malleable iron pipe, through which the phosphorus distills is then luted on, and the heat is raised to bright redness. The phosphorus distills over, and is condensed in water. It only remains to cast it in moulds, when it is sent to market. Mr. Readman, in contradiction to the usual assertions in text-books, called especial attention to the fact that mono-calcium phosphate is not used as a source of phosphorus, for the calcium takes up valuable room, and the compound requires a much more intense heat to effect its decomposition. Redonda phosphate of aluminum is regarded by the author as the future source of phosphorus, but as yet no attempt to procure phosphorus from it has been pecuniarily successful.

The President read a paper on the "*Leblanc Soda Process.*" He gave an historical *résumé* of the process of alkali manufacture, mentioning that before Leblanc brought out his process it was very probably carried on as a secret process in England. The various reactions imagined by different investigators to take place were then alluded to. Among these the following was given by Dumas:

$$\begin{cases} CaCO_3 + Na_2SO_4 = CaSO_4 + Na_2CO_3. \\ CaSO_4 + 4C = CaS + 4CO. \end{cases}$$

It was afterward supposed that an oxysulphide of calcium was formed in virtue of the equation—

$$2Na_2SO_4 + 3CaCO_3 + 12C = 2Na_2CO_3 + CaO.2CaS + 10CO + 3C;$$

and Gossage represented the reaction as—

$$2Na_2SO_4 + 3CaCO_3 + 9C = 2Na_2CO_3 + 2CaS + CaO + 10CO$$

The author then gave an account of his own researches on the subject. As it is impossible to arrive at any definite conclusion by operating on the large scale, for different samples of black ash, even when drawn with the greatest possible care from the same charge, show the most varied composition, the reaction was simplified, sodium sulphate and carbon being heated together in small quantity: the proportions and temperature were varied in each experiment. Some preliminary experiments were made, and proved that sodium carbonate is formed, especially at a red heat. At a higher temperature very little Na_2CO_3 was produced. The reaction evidently approximated to—

$$Na_2SO_4 + 4C = Na_2S + 4CO.$$

At 1,250° F. the reaction between sodium sulphate and carbon in a closed crucible is represented by the equation—

$$3Na_2SO_4 + 6C = Na_2CO_3 + Na_2S_2 + Na_2S + 4CO_2 + CO.$$

In an open crucible the excess of sulphur is burned off, and it is probable that if more carbon were added all the sulphate of sodium would be converted into carbonate. On raising the temperature the Na_2S_2 and Na_2CO_3 are decomposed, and the only products are $Na_2S + CO$.

* Read before the Philosophical Society of Glasgow

CHEMICAL NOTES.

MICROSCOPICAL PROPERTIES OF AMBER.—By O. HELM (*Arch. Pharm.*).—The clear yellow amber has no peculiar appearance when examined under the microscope; but if the opaque or white amber, cut into thin sections, be examined by a power of 200–500 diameters, round cavities, varying in size, are observed in the interior. The cavities in the milk white amber are the smallest; in the opaque yellow sort they are larger; while in the less dense quality the cavities present the appearance of a mass of soap bubbles. Water appears to be contained in the cavities, for if amber which has been laid in water for some time be exposed to an increased temperature, the weight of the specimen diminishes, from which it would appear that moisture can diffuse through the substance of the amber, and the insects which are inclosed in the substance are perfectly dry, owing to this diffusion. This peculiarity is turned to account by the amber merchants, who, to clean the amber, soak the pieces in boiling oil, whereby the cavities contract, and press out their contents, as water, lime, iron, etc. This process renders amber specifically heavier, transparent, and filled with innumerable small scale-like fissures.

Besides containing sulphur in the form of pyrites, amber likewise contains sulphur combined organically, and to the amount of 0·26 per cent. in the clear yellow sort, 0·38 in the dark, 0·34 in the bone-colored, and 0·27 in the brownish red weathered coating of the last named kind. This sulphur is contained for the most part in the bitumen which is insoluble in alcohol or ether.

The author considers that the sulphur was introduced into the amber during the tertiary period, the origin being one of two, either the reduction of sulphates originally present in the interior, or that the sulphur has diffused itself into the resin from outside. In the first case the sulphate would be reduced to a sulphide, which in its turn would be transformed into an organic sulphide, and accompanied by the production of a metallic carbonate. The evidence of the original appearance and structure of the amber still existing unaltered renders the above internal chemical change improbable. It is therefore more likely that sulphureted hydrogen, or some other easily decomposible sulphide, has been formed in the neighborhood of the amber, and that this passing by diffusion into the interior than combines with the amber.

GEDANITE, A NEW FOSSIL RESIN.—By O. HELM (*Arch. Pharm.*).—Up to the present time the substance known as "unripe amber" has been considered to be amber, but the author shows that it differs totally from true amber in its composition, and he has given it the name of gedanite. Gedanite has a hardness of 1½–2, breaks easily, and has a sp. gr. of 1·058–1·068. It does not contain succinic acid, and when heated in oil, it swells up and becomes like caoutchouc. Ether dissolves 40–52 per cent., and alcohol 18–25 per cent.; and of the residue left by evaporation of the alcohol, ether dissolves 20–24 per cent. The portion soluble in alcohol softens at 100°, and melts at 105°, and then resembles mastic. The ash amounts to 0·06 per cent., and consists of lime, silica, sulphuric acid, and ferric oxide. Sulphur organically combined appears also to be present, and, like amber, gedanite is negatively electric. Its composition is C 81·01, H 11·41, O 7·33, S 0·25. Gedanite therefore differs from amber in having a lower melting point, a smaller amount of oxygen, in being less hard, and more easily soluble in ether, and in the absence of succinic acid; and it differs from copal and other resins in containing sulphur organically combined, in having a higher melting point, and being less soluble in various liquids, and in its amber-like color when heated.

REACTION BETWEEN MERCURY AND HYDROCHLORIC ACID GAS.—By BERTHELOT (*Compt. Rend.*).—13·5 grammes of mercury and 48 c.c. of pure and dry hydrogen chloride were sealed in a tube and heated to as high a temperature as was possible for one hour. On opening the tube it was found that rather more than 1 c.c. of hydrogen had been formed, or about $\frac{1}{20}$th of the hydrochloric acid gas had been decomposed.

FORMATION OF AMMONIUM NITRITE.—By A. V. LOSECKE (*Arch. Pharm.*).—The author has corroborated Schönbein's statement that the evaporation of water in air produces ammonium nitrite, and gives the results of experiments to determine the conditions of its formation. It is found that ammonium nitrite is always formed when water evaporates freely, and the lower the temperature the larger is the quantity produced; but the formation is prevented if the evaporation takes place in a narrow-necked flask. In another series of experiments, it was observed that 1 liter of water, evaporated to a small bulk, yielded ammonia equivalent to 0·148 part in 100,000 parts of water; 1 liter, evaporated to small bulk at 40–50°, yielded ammonia equivalent to 0·5823 part of nitric acid per 100,000 of water; and lastly, 5 liters of water, allowed to evaporate spontaneously, yielded ammonia equivalent to 2·9608 nitric acid per 100,000 parts of water. This last experiment shows the influence that the evaporation of rainwater and dew can have on the nourishment of plants; and it has been found that if a leaf be moistened and allowed to dry, nitrous acid is produced, and that in dew from leaves ammonium nitrite can be easily detected. These experiments, therefore, explain the introduction of nitrogen into plants, which, Boussingault says, cannot occur directly. Ammonium nitrite can also be detected in snow and rain alone without contact with leaves, but then only in very minute quantities. The water used in the experiments was ascertained to be free from ammonia, and also from nitric and nitrous acids.

CHROMATES AND DICHROMATES—By L. SCHULERND (*Jr. Pr. Chem.*).—The results of the investigation show that only monad metals are capable of forming dichromates, and that as lithium forms a dichromate, we have here an additional proof of the monatomicity of this element. Potassium chromate and dichromate produced identical precipitates in solutions of barium salts, although the wet precipitate from the dichromate was rather darker in color; but the dichromate described in *Handwb. der Chemie*, as formed when barium chromate is dissolved in a chromic acid solution, could not be obtained; the calcium salt behaves similarly. Hot water withdraws chromic acid from the red silver dichromate. From neutral thallium carbonate, potassium dichromate precipitates a mixture of the chromate with the dichromate, whereas in acid solutions the dichromate only is formed. Lithium chromate, produced by the addition of lithium carbonate to chromic acid, crystallizes in yellow prisms with 2 mols. of water; this is driven off at a temperature of 130°. The dichromate, which crystallizes with 2 mols. of water, forms hard, almost black, thick plates; the crystalline water is driven off at 130°, and at a high temperature the crystals melt and give off oxygen.

NEW COMBINATIONS OF HYDROCHLORIC ACID WITH AMMONIA.—L. TROOST.—The author remarks that hydrochloric acid and ammonia have hitherto been obtained only in the proportions which form sal-ammoniac, analogous to common salt. No hydrochlorate of this chloride has yet been discovered, nor an ammonic hydrochlorate with excess of base. He has discovered a great number of curious compounds, formed by dry ammonia with hydrochloric acid, hydrosulphuric acids, and other acids, both mineral and organic. He takes ammoniacal gas absolutely dry and free from every trace of compound ammonias, saturates it with pure dry hydrochloric acid, and submits the sal-ammoniac thus obtained and distilled in a close vessel to the action of a large excess of gaseous ammonia, refrigerating to different degrees. He thus obtains two well-defined compounds, characterized by their point of fusion, their crystalline structure, and their tension of dissociation. The former of these, tetra-ammonic hydrochlorate, $HCl.4NH_3$, melts at +7°, and its crystals depolarize light powerfully. The other compound, hepta-ammonic hydrochlorate, $HCl.7NH_3$, melts at —18°.

MALABAR GUM KINO AND A NEW COMPOUND, KINOIN.—C. ETTL.—The author added kino to twice its weight of boiling dilute hydrochloric acid (1 : 5). Kino-red separates out as a soft mass, which slowly hardens on cooling, while the kinoin remains in solution, contaminated with a little kino-red. When purified it crystallizes in colorless well-formed prisms, sparingly soluble in cold water, readily at a boil, and very easily in alcohol of every concentration. The solution is not precipitated by glue and is colored red by ferric chloride. The composition of kinoin is $C_{14}H_{12}O_6$.

TROPÆOLIN AS AN ALKALIMETRIC INDICATOR.—DR. LUNGE.—The author confirms the statements of Miller concerning the use of tropæolin OO for the titration of sodium carbonate, and for determining the free acid in alumina. Not merely the carbonate but sodium sulphide (in the crystalline state) may be accurately titrated in the cold with sulphuric acid, using tropæolin as indicator. On the slightest excess of acid appearing, the yellowish color changes at once to a magenta and then to orange, which after a few seconds disappears entirely. Tropæolin OOO undergoes the reversed play of color, being yellow in acid solution, but turning to a magenta red in alkalies.

ON AURIN.—R. S. DALE and C. SCHORLEMMER.—The authors describe their conversion of "red corallin," or "peonin," into rosanilin. They have further examined ammonia-aurin, tetrabrom-aurin—which latter compound is very similar to tetrabrom-rosolic acid, soluble in alkalies with a fine violet color, while its acidified solutions dye silk and wool a dark violet. They have further investigated the action of acetyl chloride and anhydrous acetic acid upon aurin. The compounds of aurin with acids are red like the aurin itself, while those with the acid sulphites of the alkali metals and with anhydrous acetic acid are colorless like leukaurin. The homologue of aurin rosolic acid likewise forms with acids well crystallized compounds, and as a powerful base. Hence it should not be considered as an acid, and might be more appropriately named rosaurin.

AN ELECTRIC BLOWPIPE.—M. JAMIN.—The author remarks that the electric arc which plays between two carbon conductors is a true current. If submitted to the influence of a neighboring current, of a solenoid, or of a magnet, it experiences an action regulated by the laws of Ampère, identical with that experienced by any metallic conductor put in its place, but as its mass is exceedingly trifling its speed is considerable. The author takes advantage of this fact to submit small quantities of matter to an intense heat. By causing the arc to be driven upon lime, magnesia, or zirconia, the light is directed downward, and its intensity is increased at least threefold.—*Comptes Rendus.*

THE OXIDE OF NICKEL, Ni_2O_4.—By H. BAUBIGNY (*Compt. Rend.*).—When oxygen is passed over nickel chloride at a temperature of 440°, the chloride is, after some time, completely transformed into a crystalline insoluble substance, which is no other than the oxide Ni_2O_4. The action is much more rapid with moist than with dry oxygen. This oxide of nickel, which is analogous to magnetic oxide of iron, cannot be made to furnish an oxide of a higher degree of oxidation, but by a strong heat it is reduced to the protoxide, NiO.

SPECIFIC HEAT, AND LATENT HEAT OF FUSION OF PALLADIUM.—By J. VIOLLE (*Compt. Rend.*).—The method employed for the determination of the specific heat of platinum between 0° and 1,200° was adopted for the determination of the specific heat of palladium between 0 and 1,300°. The author gives a table of results obtained, and compares them with the numbers calculated from the formula (1) $C_0^T = 0{\cdot}0582 + 0{\cdot}000010T$. The true specific heat at T°, $\frac{dQ}{dT}$ is equal to (2) $g_T = 0{\cdot}0582 + 0{\cdot}000020\,T$, from which $g_0 = 0{\cdot}0582$, $g_{300} = 0{\cdot}0682$, $g_{1000} = 0{\cdot}0782$, $g_{1300} = 0{\cdot}0842$.

The temperature of fusion of palladium has been determined:

(1.) By heating a solid piece of palladium as near to the melting point as possible, plunging it into a calorimeter, and calculating the temperature to which the metal has been heated from the specific heat given by the formula (1).

(2.) By heating a mass of platinum by the side of a mass of palladium and obtaining two temperatures very near to each other, such that at one the palladium melts, but not at the other, these temperatures being in each case determined by means of the platinum, by the calorimetric method. By these methods the temperature of fusion of palladium is found to be 1,500°. It is noteworthy that palladium, like platinum, softens before it melts, so that it can be welded at a temperature somewhat below 1,500°. The total heat of fusion according to the mean of three experiments is 146·1 th. units for 1 gramme of palladium, and by deducting 109·8 th. units, the quantity of heat necessary to raise 1 gramme of palladium from 0° to 1,500°, the latent heat of fusion of palladium, is found to be 36·3 th. units.

ON ASPHALT AND OTHER RETINALITES.—By O. HESSE (*Arch. Pharm.*).—To determine the amount of sulphur in asphalt bitumen, and in what form the sulphur existed, whether as sulphates, or pyrites, or organic sulphur compounds, a portion of asphalt was incinerated, and the sulphuric acid and iron were determined in the ash. Another portion treated with strong nitric acid gave the amount present as sulphide; and by the fusion of a third portion with sodium carbonate the amount of organic sulphur was determined. The experiments show that sulphates and sulphides are present only in very small quantity, whereas organic sulphur exists to the amount of 10·85 per cent. Sulphur is not found free in asphalt. It is probable that the formation of organic sulphur compounds is due to the generation of sulphureted hydrogen by the action of organic matter on calcium sulphate in the neighborhood of the asphalt, which passes by diffusion into the interior of the mass, and then replaces oxygen by an equivalent of sulphur. The large amount of sulphur that was found organically combined in asphalt made it probable that experiments on coal would show that sulphur was also present there in a like state. Such proved to be the case, for when powdered coal was submitted to a temperature of 180°, a small amount of sulphureted hydrogen was evolved, a slight rise of temperature produced a clear distillate, and at 320° an oil passed over, which turned brown in the air, and contained sulphur. Elaterite contains 1 per cent. of organic sulphur, a yellow retinite 0·4 per cent., and iron only in traces. This specimen yielded free sulphuric acid when treated with water, the acid being formed by the oxidation of the sulphur compound on the surface. A specimen of walkowite gave strong indications of sulphuric acid when washed with water, and contained 0·72 per cent. of sulphuric acid, and 0·73 per cent. of organic sulphur. Under the microscope a number of fine bubbles were seen in the interior of this specimen. Dopplerite and ozokerite contain no organically combined sulphur.

RECIPROCAL DISPLACEMENTS BETWEEN OXYGEN, SULPHUR, AND THE HALOGENS, WHEN COMBINED WITH HYDROGEN.

By BERTHELOT (*Compt. Rend.*)

IT has been already shown that when any two of the above elements, entering separately into combination with a third, evolve different amounts of heat, the element which evolves the greatest amount of heat will, under suitable conditions, displace the other from its combination with the third. Chlorine, therefore, displaces bromine and iodine, and bromine displaces iodine, both in the gaseous hydracids and in their aqueous solutions. In like manner chlorine and bromine ought to displace sulphur from hydrogen sulphide, both in the gaseous state and in solution; but although iodine should displace sulphur in dissolved hydrogen sulphide, sulphur, on the contrary, should decompose hydriodic acid gas, with formation of gaseous sulphureted hydrogen, since the union of hydrogen and sulphur to form gaseous H_2S evolves + 3·6 units of heat, while 0·8 unit is absorbed in the formation of hydriodic acid gas. The author has made new experiments upon this point.

Dry hydrogen sulphide was inclosed with a little iodine in a sealed tube, and heated to 500°, but no reaction took place. On the other hand, dry hydrogen iodide and sulphur in a similar arrangement reacted immediately, even in the cold, and on heating to 100° the reaction was complete. When the tube was opened under water, the rising of the latter showed a diminution of nearly one-half the volume of the gaseous contents of the tube; the inverse action then immediately sets in, and the hydrogen sulphide is decomposed in its turn by the sulphur iodide formed, reproducing sulphur and solution of hydriodic acid. These two inverted actions can be effected, even in presence of water, with a solution containing more than 52 per cent. of hydracid; if iodine be dissolved in it and hydrogen sulphide passed into the solution, no ultimate reaction is observable, because the liberated sulphur attacks and destroys the hydrogen iodide as fast as the latter is formed.

Oxygen should and does displace sulphur in hydrogen sulphide, but between chlorine and oxygen theory indicates that an equilibrium might be produced. Gaseous chlorine ought to decompose water, when hydrated hydrochloric acid is formed, but, on the contrary, oxygen ought to decompose anhydrous hydrochloric acid, with formation of water and chlorine.

1. A gaseous mixture of hydrogen chloride and oxygen, in proportion of 4 vols. of HCl and 1 vol. of O, was inclosed in a tube, and submitted to the action of the electric spark for some hours; nine-tenths of the mixture was decomposed, with formation of free chlorine and water.

2. Inversely, a weighed quantity of water, inclosed with free chlorine, was decomposed in a similar arrangement to the extent of one-tenth of the oxygen being liberated.

The former reaction takes place easily, when the mixed gases are passed through a red-hot porcelain tube, and the latter reaction, as is well known, occurs by itself at the ordinary temperature, especially in presence of solar light.

The theory was further verified by the author's experiments on the action of oxygen on hydrogen bromide and iodide; in both these cases, it should displace the halogen in the compound, whether the combination be gaseous or in solution; the results showed that the decomposition of the acid was complete at a temperature of 500°, while all attempts to effect the inverse action entirely failed.

In continuation of this subject, Berthelot draws attention again to facts which he has established, namely, that reciprocal displacements between acids united to one and the same base, are regulated entirely by the thermic value of the reaction, whenever the acid forms but one salt only, not decomposible by water, either wholly or in part; but that on the contrary there is a division of the base between the acids whenever the acid which evolves the greatest amount of heat forms with the base an acid or neutral salt, partially or progressively decomposible by the solvent. He now shows that this distribution also results when any two weak acids, such as hydrocyanic, boric, phenic, hydrosulphuric, or carbonic acid, react with an alkaline base.

Thus with hydrocyanic and boric acids we have—

KCN reacting with HBO_2 evolves 4·2 units.
KBO_2 " " HCN absorbs 2·9 "

the distribution of base being shown in the one case by a disengagement of heat; in the other by an absorption, the latter resulting from the partial decomposition of the reacting salts under the influence of the solvent.

In a similar manner, when potassium cyanide reacted with phenol, a division of base between the two acids took place, very nearly in the proportion of 2 : 5; with potassium phenate and boric acid, however, the latter almost entirely displaced the phenol

Hydrosulphuric acid in presence of an excess of bicarbonate saturates itself almost completely, but with equivalent quantities it takes nearly seven-eighths of the base.

The total thermic effect in reactions of this kind is the resultant of two phenomena: (1) a disengagement of heat due to the combination of the acid with the free base; and (2) an absorption of heat due to the decomposition produced by the solvent. This resultant is generally, but not always, of contrary value for the two inverse actions.

GAS AS FUEL.

IF the numbers expressing heat-units become cumbrous, as would probably be the case in dealing with any considerable weight of fuel, they may be reduced by dividing by 966, which would give the weight of water at 212° evaporated into steam at 212°; or, by dividing by 1146, which would give the weight of water at 32°, raised to boiling point and evaporated. Thus a pound of coal would raise 12·46 lbs. of ice-cold water into steam, while a pound of rectified petroleum would so evaporate 24·13 lbs. of water, and a pound of coal gas would evaporate 19·06 lbs. Otherwise expressed, to raise a gallon of water at freezing point to steam, at atmospheric pressure, would require 0·80 lb. of coal, and 0·41 lb. of petroleum, or 8·52 lbs. of coal gas. Or the (apparent) loss of heat due to the proportion which becomes what is called latent, when steam is produced, may be avoided, and in this form we may express the heating effect of a pound of coal to be equal to raising 79·38 lbs. of water from freezing to boiling point, while an equal weight of mineral oil would boil 153·4 lbs. of water, and a pound of coal gas (which would, with a specific gravity of 0·426 under standard pressure and temperature, occupy 32 cubic feet) would boil 121·39 lbs. of ice-cold water.

But we have seen that the useful effect of coal is reduced by loss of heat by means of ashes, and the difficulty of insuring its complete combustion into carbonic acid, so that not more than about 60 per cent. thereof is actually available, even in favorable cases; thus diminishing the weight of water which would be actually boiled to about 48 lbs., whereas the loss in the cases of oils and gas may be considered very trifling, and, in fact, may be almost ignored, especially in the case of gas. Making, however, a slight allowance, it may be stated that the weights of freezing water which could be boiled by a pound of each of these three fuels would be—coal, 48 lbs.; coal gas, 120 lbs.; mineral oils, 150 lbs. It must be remembered that each fuel is supposed to be exerting its full average energy under conditions similarly favorable all round.

Under such circumstances, and taking the average cost of the materials in London, the cost of boiling, by one operation, 1,000 gallons of water at 32° would be—with coal, 1s. 10½d.; gas, 9s. 4d.; mineral oils, 12s. 6d. But these figures are susceptible of much modification, when, instead of assuming equally favorable conditions for each kind of fuel, the actual circumstances are taken into consideration. The majority of gas, coal, and oil users do not require to boil such a large quantity of water, and the same prices would not hold good proportionately for fractional weights. Only for oil and gas could such a result be divided with anything like an approach to accuracy, because it is only in the cases of liquid or gaseous fuel that large and small volumes can be burnt with equal facility.

Not that there is no advantage in the combustion of such fuels in large volumes, for it must be evident that, under such conditions, it is possible to utilize some of the heat lost by radiation in warming the air surrounding the flame; but this advantage is not sufficiently valuable to prejudice the truth of the practically infinite divisibility of fuels of these descriptions, as compared with coal. For instance, although 278 lbs. of coal would boil 1,000 gallons of water, it would be practically impossible so to utilize the energy of 2·08 lbs. of the same coal as to boil a gallon of water with it. The comparative sluggishness of its action with oxygen necessitates a certain bulk of the fuel being kept in a state of incandescence, in order that the carbon and hydrogen may be consumed with sufficient rapidity to afford any useful effect. As a matter of fact, it has been found that about thrice the weight of coal above stated would be required, even when a fire is made up for the purpose of testing its performance, and it is not too much to assume that, under ordinary conditions, household fires are kept at least twice as large as in the case of an experiment, in order to avoid the risk of burning low, and to save the trouble of continual feeding. We are, therefore, led to the conclusion that, with slight exceptions, barely one-seventh part of the vast amount of coal which is burnt in the United Kingdom for culinary and other household purposes is really utilized, the remainder being absolutely wasted.

These reflections are based, it is scarcely necessary to state, on considerations of work only; the question of warming apartments, etc., not entering for the present into the scope of these inquiries.

Returning to the question of the cost of boiling water, which we have taken as our standard of effect, and bearing the above-mentioned observations in mind, we shall find that the ordinary cost of boiling 1,000 gallons of water, in small quantities and at various times, would be about as follows: With coal, 13s.; mineral oil, 12s. 6d.; gas, 9s. 4d.; and if to the cost of coal is added that of kindling wood, etc., and the waste which goes on by means of the fire having to be kept up when doing no actual work, in order that it may be ready when required, the disparity is yet greater.

The conclusion to which we are led in the foregoing paragraph is somewhat curious. It could scarcely have been expected that it would be more economical to burn gas than coal, seeing that the one is manufactured from the other, and is sold at a price which has to cover the cost of manufacture and distribution, in addition to the prime cost of the raw material. The advantage to the consumer is to be found solely in the difference in degree of adaptability of the two forms of matter—in the greater facility with which the energy of gas can be made available as and when required.

The competition between gas and mineral oil as fuel is remarkably close. Nothing could detract from the advantages derivable from the portability of petroleum, save the danger attending it when heated, which must always be the case when the reservoir of oil is in such proximity to the point of combustion as is essential to the due development of the heating effect. It is impossible to contemplate the progressive increase in the construction of oil-stoves for every household purpose, and the portentous dimensions to which some already attain, without reflecting on the danger caused by the exposure of such a highly inflammable material as mineral oil in reservoirs—often of slight construction—to the certainty of a considerable and perhaps unknown increase of temperature, and, from the very purposes which these utepsils are designed to serve, generally in ignorant and unskillful hands. It is, of course, maintained by the manufacturers of these articles that, with a suitable oil, there is no danger attending their use; but when a stove of such a description is once adopted in a household, and the carelessness which familiarity brings supervenes, the suitable oil being exhausted, anything which smells like it is put in, and the result is not difficult to foresee.

Digressing for a moment from the main purpose of this article, it is easy to comprehend that the calorific power of mineral oils is anything but an advantage when they are used as illuminants. From the high place which they hold as fuel, it is evident that their use for lighting purposes must be attended with an excess of the heat which is sometimes complained of in gas.

Turning, in conclusion, to the dynamical effects of the combustion of gas, we shall find some curious facts. The energy required to raise a pound of water one degree of Fahrenheit's thermometer, is capable of raising a weight of 772 lbs. to a height of one foot, or 1 lb. to a height of 772 feet. By the table previously given we find 100 cubic feet of gas will exert a force of 69705·647 units, or, in other words, is able to raise a weight of 24,023 tons one foot high, or lift one of the gigantic 81-ton guns from the Woolwich Arsenal to a height of nearly 300 feet. Supposing this energy could be developed in one minute, its equivalent in horse power would be 1,630. An ordinary gas-burner, consuming 5 cubic feet per hour, exerts in that time energy sufficient to lift 1,201 tons a foot high, or more force than would be necessary to raise a man of 13 stone to the summit of Mont Blanc. Every minute during which such a burner is alight it is doing work equal to 1·35 steam-horse. Supposing, for example, that the consumption of gas in London is 100,000 cubic feet during any minute, the force which such a quantity represents is equal to raising a weight of 718·6 lbs. to a height equal to the distance which separates the earth from the sun; or the power of 2,112,392 horses is required to light this metropolis for a single minute of a winter's night.—*Journal of Gas Lighting.*

IMPROVED HYDRO-EXTRACTORS, COMBINED WITH ENGINES.

THE use of hydro-extractors has greatly extended of late years, as they save much time to dyers and cleaners, cloth finishers, and sugar boilers. In chemical works, baths and wash-houses, extensive laundries, and many other establishments, where it is required to dry large quantities of linen or other substances, without loss of time, these machines are no less invaluable.

A whole series of hydro-extractors (*essoreuses*) from 30 centimeters to 1 meter (11 to 39 inches) in diameter, was shown at last year's Paris Exhibition by MM. Pierron et Dehaitre, who were rewarded with a gold medal by the jury of Class 60, having already carried off the medal for progress at Vienna, in 1873. Fig. 1 shows the simplest form of this machine for being driven by hand, with a winch screwed on to the horizontal shaft, or by a belt from an engine. This type is made in small sizes, and is most suitable for small establishments; even when turned by hand, it is capable of making from 1,500 to 1,800 revolutions a minute. In Fig. 2, half the arched frame carrying the motion is suppressed, so as to afford greater facility for filling and emptying the pan or revolving cylinder. This arrangement cannot, however, be adopted for large sizes, as there would be too slight support for the gear. In order to obviate this difficulty in large sizes, and at the same time to give perfectly free access to the pan, the above-named firm have arranged the motion below instead of above. This class may be driven either by a belt or by a small inverted cylinder engine, of about 1 horse-power, attached to the side, acting directly on the main shaft, as shown in Fig. 3, in which latter form it is made from 60 to 120 centimeters (23 to 47 inches) in diameter. This combined arrangement is found very suitable for dyers and cleaners; and in baths and wash houses, where there is a steam boiler, but not an independent engine. The last new combination is that shown at Fig. 4, which, not being limited in size, is suitable for large dyes and chemical works.

FIG. 1.

FIG. 2.

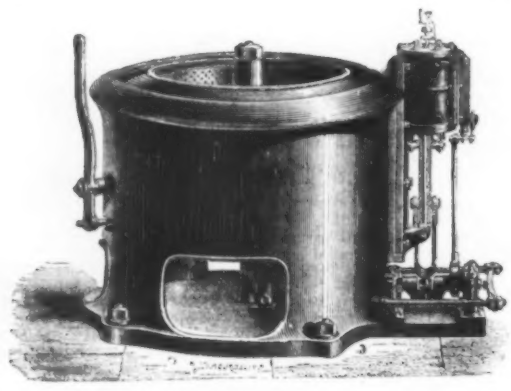


FIG. 3.

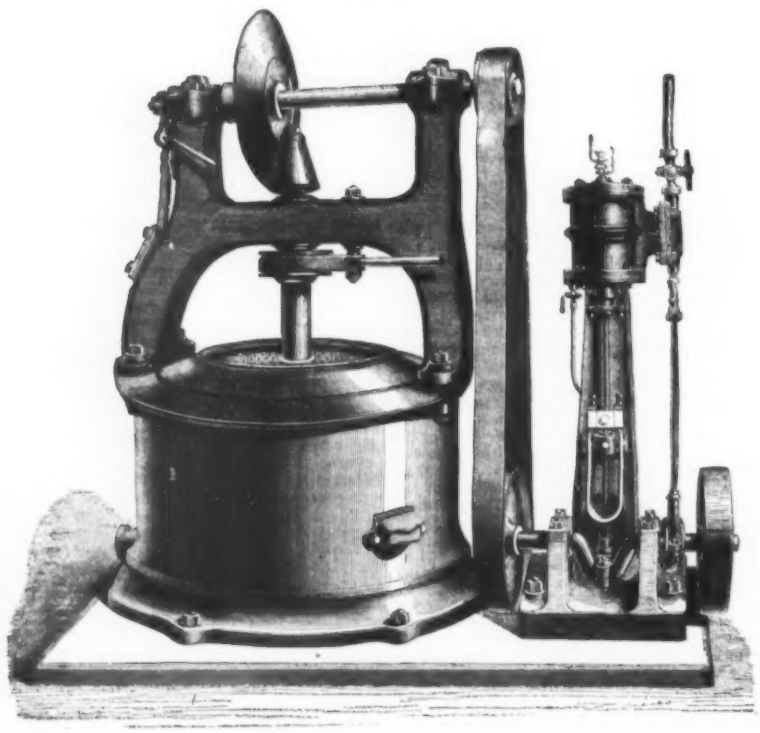


FIG. 4.

IMPROVED HYDRO-EXTRACTORS, COMBINED WITH ENGINES.

The large size of the hydro-extractor affords sufficient room to get at the pan for filling and emptying, notwithstanding the frame at the top. The crank shaft of the inverted cylinder engine, beginning from 4 horse power, has an extra driving pulley for working a second hydro-extractor or other machinery—a gasing machine for instance.

The gear in all these various types is frictional, a cast-iron cone pulley on the horizontal driving shaft giving motion to one made of paper on the vertical shaft, in the proportion of 5 to 1, so that a high speed of pan is attained. The contact of the two cone pulleys is maintained by a laminar spring acting on one end of the horizontal shaft; but the pressure may be removed, when not working, by a small cam turned by a handle. This arrangement has the advantage of allowing the pressure to be put on gradually at starting until the requisite speed is attained. A strap-brake lined with leather is provided on the vertical shaft for stopping the pan's revolution quickly, if required. The vertical shaft is made of untempered steel; and the upper bearing, of hard gun-metal, is made conical so as to compensate for wear; it is moved down by nuts, one above and one below the frame. The pivot and the step are of hardened Styrian steel; and the latter is raised above the bottom of the case, so that the pivot may always revolve in oil free from impurities. The lubrication of the upper bearing is effected by pouring oil down a small channel in the shaft, whence it is distributed evenly over the surface in contact. The horizontal shaft revolves in bearings provided with reservoirs, and a small chain constantly raises oil to the upper surface of the shaft. Unless otherwise ordered, the pan is made of copper and tinned after perforation, both inside and out, so as to resist the action of acid. The cover is in two halves, which, after being adjusted in their place, are held down by a hand-screw. A cock is provided for letting off the water expelled through the holes. The bolts connecting the frame to the base are made to fit tight in their holes, for the sake of insuring rigidity with such rapid motion. With a slight amount of care in filling the pan, so as to equalize the weight, these machines run very smoothly and with scarcely any noise; they are very strong, simple, and well made, while they also have the merit of possessing very few parts in motion.

The manufactory was started at La Chapelle, Paris, in the year 1867, by M. Pierron, late foreman of the Gouin works, and M. Dehaitre, foreman to the Maison Lecoq, chiefly for the production of machines required in the dyeing trade, while those for the paper trade, printing, and binding, form a second specialty.—*Iron.*

IMPROVED CHROME BLACK ON WOOL.

IN a recent lecture before the German Chemical Society, Dr. M. Reimann made the following suggestions:

Two methods have heretofore been principally followed to dye woolens black, the chrome and the iron bath, the coloring principle being furnished by logwood. Chrome black was formerly obtained by a solution of bichromate of potash slightly acidulated with sulphuric acid. The action of the latter made the wool very harsh and rough. Later the process was somewhat improved by the addition of cream of tartar and sulphate of copper. Cream of tartar reduces all the free chromic acid to oxide, and the color produced has a greenish tint in consequence. Sulphate of copper converts this into blue. If neither is used the intensity of color and its shades varies at different spots, as a portion of the fibers is yet coated with a solution of free acid, while at other places the latter has already been converted into oxide. To these disadvantages must be added the sensitiveness of chrome black toward alkalies; solutions of the latter of medium strength even destroy it. The sunlight imparts to it a green tint.

Iron black, produced by sulphate of iron, blue vitriol, cream of tartar, and logwood, is very stable and intense, but has the drawback to be destroyed by acids.

Reimann has recently been experimenting with a view of combining the advantages of the two processes with the exclusion of their drawbacks.

Starting from the fact that chrome yellow is formed by the action of sulphuric acid on bichromate of potassium in the old process, he substituted chrome alum altogether for those two chemicals, and obtained the best results, the chrome oxide being fixed on the fiber similarly as alumina in the presence of cream of tartar. The color produced is a dark slate gray, and the intermediation of an oxidizing agent is necessary to produce a jet black.

Reimann now combined the iron process above mentioned with the chrome alum process, and obtained a beautiful black, which resisted the action of acids, alkalies, and the sunlight.

Another advantage consists in the cheapness of the material. Chrome alum is produced in large quantities as an accessory product by many chemical works. It crystallizes with difficulty only, and as its use and the demand for it were heretofore very limited, the manufacturers preferred to let the solutions run off with the waste water.

For dyeing, however, the solutions may be used without any further evaporation, and while the manufacturing chemist will be glad to obtain a moderate price for anything hitherto valueless, the dyer will be able to furnish with the cheapest material a better dye than heretofore obtainable.—*Deutsche Gewerbe Zeitung.*

CHEMICAL ITEMS.

[Journal of the Chemical Society.]

ELECTRO-CHEMICAL ACTIONS UNDER PRESSURE.—By A. BOUVET (*Compt. Rend.*).—The author has made a series of experiments on the decomposition of water by electricity when the products are confined so as to exercise a pressure equal to that of several hundred atmospheres. He finds that the amount of water decomposed, and the quantity of electricity required for that purpose, are independent of the pressure, also that the temperature remains sensibly constant. The results are in perfect accordance with the theoretical formula for the work done in compressing the gases. Oxygen and hydrogen are liberated with equal facility, and may be collected together or separately. Contrary to the received view, there was in all cases an absence of any secondary phenomena indicating a recombination, the manometer for hours indicating a perfectly regular increase of pressure, minute by minute. There was no danger of detonation when the gases were collected in one vessel, even when the pressure was considerable, as care was taken to keep the electrodes, which were of platinum, completely immersed in the liquid.

GAS REGULATOR FOR AIR BATHS.—By L. CRESTI (*Gazzetta Chimica Italiana*).—This regulator somewhat resembles Bunsen's, but the air chamber of the instrument alone is inside the air bath, and communicates with the part containing the mercury by means of a tube. As the air expands, the pressure causes the mercury to rise and partly closes the tube by which the gas enters. It has the advantage over Bunsen's regulator that the mercury has not to be heated, and therefore it is more sensitive, but it has the same defect of being affected by barometric changes; this is avoided in Page's regulator.